ENGINEERING

issue

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HIGH TENSILE STEEL

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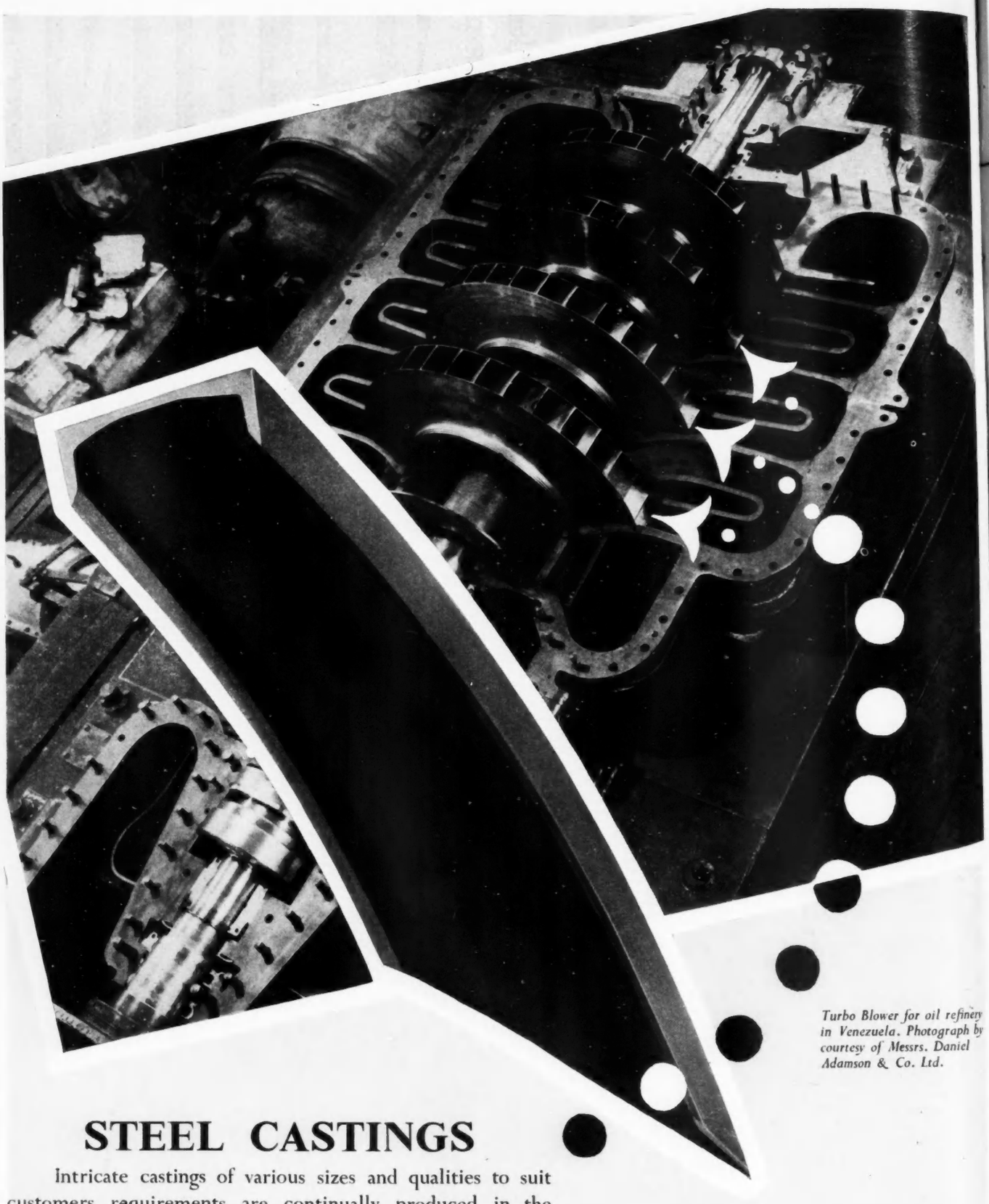

Turbo Blower for oil refinery in Venezuela. Photograph by courtesy of Messrs. Daniel Adamson & Co. Ltd.

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Life Class

MR. Khrushchev's recent pronouncements on education in the USSR seemed at first to be largely political. Everyone, regardless of his family connections, must experience the dignity of manual labour. This was good political propaganda for the masses in other countries. It reaffirmed the egalitarian aspect of Communism. In fact, the political flavour of the pronouncements is of minor importance. The practical consequences, on the other hand, are of great interest. An educational system which has already astonished the world by its achievements in engineering is about to be recast.

Briefly, the intention is that instead of ten years at school from the age of seven, every boy and girl will have not more than seven or eight years, after which he will be required to engage in productive work on a farm or in a factory for at least two years before he can enter a university. During this two years or more, study will be part-time, so as not to interrupt production, and it will be only those who show, during this period, that they are worthy of higher education who will go on to university. The present ten-year system is regarded as unsatisfactory because the youths it turns out all want to go on to university although there are not places for them all. The disappointed ones despise the physical work which they are obliged to take up, and they and their parents accept the situation reluctantly. Parents who can exert influence or bring pressure to bear sometimes manage to get their children into higher education in spite of poor examination results. These defects in the system will disappear if Mr. Khrushchev's proposals, after discussion and final drafting, are put into effect.

An engineer who examines these proposals quite objectively, forgetting the political overtones, would agree that a period of honest manual work should do no youth any harm and do many of them much good. A gap in full-time education has the obvious disadvantage that continuity of learning is destroyed, but the experience of British universities after the war, when young men came back to their studies more mature than they would have been if they had gone straight from school, suggests that more is gained than is lost. A boy of intellectual ability may readily acquire factual knowledge at university which will be useful to him in later life, but he may fail to derive the full benefit of a university education because his frame of reference—his experience of life—is as yet so limited that the discussion, the argument, the interplay of inquiring minds which characterises a university, is outside his comprehension. We in this country cannot afford to give young men the privilege of university life if they are not capable of benefitting from it (which is partly why some eminent professors hold strongly that three years is enough for a degree course); they must get out into the world and make room for others—they can come back later on postgraduate courses when they will be able to give more and gain more. The University Grants Committee in Britain examine this and related questions very fully in their latest report (*University Development*, 1952-1957) and they stress that "the acquisition of specialised knowledge is not the only, or the most important, benefit which the student should derive from his course."

The Soviet proposal, therefore, far from lowering standards, may effect a pronounced improvement. Its effect on equality of opportunity is perhaps even more significant. In every educational system there must be a screening point—usually several—at which the bright ones are passed on to greater opportunities and the rest have to accept the unpalatable truth that they are sub-standard. A recent study in this country by Dr. Joseph Trenaman on behalf of the BBC has shown that those who are rejected become "resisters" to education, and the gap between them and the fortunate ones grows wider with the years. In Britain the first main screening point is at the age of eleven; in the USSR, if the proposed system is adopted, the main screening point will be moved from the later years of full-time schooling to the stage when the young person has acquired the self-confidence and broader vision which a working life imparts.

This is a change of fundamental importance which may well, produce even more remarkable results than the present system. At the same time, it will give an immediate saving in teachers because of the shortened period of normal schooling, it will increase the number of productive man-hours available to Soviet industry, it will ensure that needless time and energy are not wasted on educating the mass of people beyond the stage at which it ceases to be worthwhile for the State, and it will extend the system of night schools, which we regard as the 19th century "hard way," though it built Britain into the greatest industrial power in the world. By considering the Russian proposals we may find it easier to examine our own system critically.

Cover Picture.—*After hardening, steel balls for bearings are precision ground to a high degree of accuracy. The picture shows a sample ball being gauged during the course of the grinding operation —one of the many inspections made during manufacture of bearings.*

(*Nurnberg photograph for* ENGINEERING)

* * *

Plain Words

There is something rather tiresome about those people who are always on the look-out for signs of waste and inefficiency in others. No doubt some of them do a good job by drawing public attention to scandalous situations, but on the whole I wish they would spend more time looking for faults in themselves; it's a much more difficult exercise but it's vastly more rewarding. But even that has its snares: the man who says "I know I have my faults, like everyone else" is in danger of saying it with an air of "—but I put up with them," while everyone else detests them. Anyway, I salute Mr. Andrew Shonfield for taking the lid off a very interesting stew. It's worth looking in the pot.

Writing in a national Sunday newspaper, he suggested that in the nationalised industries cuts are still being enforced that are seriously interfering with the development which is the real object of policy. The case of the National Coal Board is particularly interesting. Here the problem is a surplus of small coal and a shortage of large lumps. The Area Boards have taken delivery of a number of large coal cutters designed to produce the large coal that is so badly needed. Does this mean that improved technical efficiency is going to get the coal industry out of its economic difficulties? Not at all. Some of the machines have gone into service and are working at the seams. But others are being deliberately held as "stores."

The reason for this strange behaviour is all a matter of book-keeping. A coal cutter in use is a piece of capital investment. If it is put in a shed, or even left on the pit bank with a tarpaulin sheet over it, it is an item of stores and does not count against the Treasury's allowance for investment for this year. The allegation that this holding up of valuable machinery was taking place was made several weeks ago. Since then the National Coal Board have apparently issued no public denial of its truth. The manufacturers of coal-cutting machinery are said to be alarmed at this peculiar stock-piling of their products. While Coal Board officials are maintaining a tight-lipped attitude to inquiries there seems to be little doubt that this is a case where official policies are just not being translated into practice in a way that is anywhere near meeting the needs of the industry. To cut capital spending in this furtive manner is clearly nonsense. If it is taking place, the National Coal Board should put a stop to it at once. If it is not then a prompt denial should have been issued. As this has not happened it looks as though we are being treated to a policy of maximised waste.

CAPRICORN

Weekly Survey

Saving Fuel by Maintenance

A series of technical meetings was concluded last Wednesday in connection with the Industrial Fuel Efficiency Exhibition at Olympia. At these meetings a number of papers were read under the auspices of the Institute of Fuel with the overall title "Lower Costs and Higher Production through Better Fuel Utilisation." Mr. J. C. Veale, in a paper entitled "Planned Maintenance," drew attention to the importance of efficient plant maintenance in relation to economy in fuel consumption.

Apart from the obvious cases of fuel wastage due, for example, to a leaking steam valve, Mr. Veale pointed out that whenever steam or fuel utilising plant breaks down, fuel is almost always wasted. Similarly, fuel losses are likely to result from inadequate maintenance of instruments. Thus, the advantages of an efficient planned maintenance scheme should cover not only reduction in maintenance costs and in loss of output but also improved quality of the product and reduced fuel consumption per unit of output.

Objections to planned maintenance schemes are almost always on the score that they are over-elaborate and that money is being spent unnecessarily. Certainly the more efficient the scheme the more does this appear to be the case to those who do not remember a previous period when no such scheme was in operation. After describing a maintenance control scheme in considerable detail, Mr. Veale set out a number of yardsticks for measuring the success of any such scheme. These should prove of considerable value to the works engineer who is convinced of the value of planned maintenance but must justify it to higher authority.

Mr. Veale expressed the opinion that in the installation of planned maintenance schemes, there are a number of advantages in employing outside consultants. In particular, the consultant will have had experience of installing schemes for other companies, the work involved is usually a full time job and there resistance of all grades of management is more readily overcome if the inquiries and recommendations are made by outsiders.

Refinery at Milford Haven

Esso's Fawley refinery has been in operation for some time. Now the same company is to build a new refinery at Milford Haven. A new plant is needed because Fawley has reached its maximum practical size. It cost over £30 million to build and as much again has been spent in its enlargement and development. Over 10 million tons of crude oil are processed each year at Fawley, that is around 28,000 tons a day, seven days a week. The new site has been chosen with an eye to the future.

At Milford Haven it is possible to berth the largest ocean tankers at all states of the tide. Tankers of 100,000 tons deadweight or more can be safely handled at all hours of the day. Although Milford Haven has no local market it is well placed for receiving crude oil. The refinery and marine installations will take about two years to construct and cost about £18 million. In the first instance it is designed to process about 4½ million tons of crude oil a year, but future expansion is allowed for.

Crude oil tankers mainly from the Middle East will unload at the marine terminal. The distillation unit at Milford Haven will be 50 per cent larger than the biggest of the three units at Fawley. The company expect to employ from 400 to 600 people when the refinery is completed. The principal products will be petrol and turbojet fuels, diesel oils and marine and industrial fuel oils. Much care is being taken in the siting and planning of the refinery and Esso hope to prove that a modern industrial plant will impinge as little as possible on the familiar Pembroke landscape.

Nordic Free Trade Area

Time was not so long ago when the Free Trade Area was expected to overtake the proposals for a Nordic customs union. For some time the comparatively bold conception of a Nordic Economic Union was put into the shade by the grander scheme of the Free Trade Area for the whole of western Europe. It is now just possible that the Nordic union may begin to function before the Free Trade Area.

Last week the Nordic Economic Co-operation Committee issued a report to say that the re-creation of a customs union between Norway, Sweden, Finland and Denmark would strengthen Scandinavia's industries in an eventual Free Trade Area. The report calls for the immediate dismantling of tariffs among the four countries. The Nordic council will be considering the report in November and if it adopts the proposals the whole wide range of industrial equipment and consumer goods will be affected. It is proposed that agricultural products should be left out of the scheme and that the duty on motor-cars should be progressively reduced. Apart from this, Scandinavia will be virtually a Free Trade Area in time if the report is adopted.

There is much to be gained by the Scandinavian countries, especially by Sweden, if their economies can have a trial run under a free-trade system. If the Nordic Economic Union could be fully established before the FTA negotiations seriously begin, Scandinavia could offer a united front to the rest of Europe round the negotiating table.

Moving What Comes Naturally

Since 1950 consumption of natural gas in the free world outside the United States has increased by almost 3½ times. United States consumption in the same period has gone up by two thirds and represents the bulk of the world's consumption. Last year apart from the United States the free world consumption represented the equivalent of 19 million tons of fuel oil. In Western Europe the greater part of the increase likely in the next two years will come from the Lacq field in France. Increases are also forecast for West Germany, Austria, and the Netherlands. In Italy by contrast, little immediate increase is likely, but production there is the highest in Europe. Further increases in the use of natural gas will depend on new discoveries and wider systems of distribution.

So far as Britain is concerned it will be necessary to overcome the obstacle of transport if there is to be any extension of the use of natural gas as fuel or in the petrochemical industry. If next year's experiments in the ocean transport of deep-frozen natural gas by specially built-ships should prove a technical and economic success an entirely new field of growth could be opened up. Natural gas would acquire some of the flexibility that oil now has.

Preliminary estimates show that ocean transport might cost 0·6 cents per thousand cubic feet per 100 miles. This would still be three or four times the cost of carrying an equivalent cargo of oil by tanker, but less than half the average long-distance pipeline cost which in the United States is about 1·5 cents per 1,000 cu. ft per 100 miles. A considerable investment in liquefaction plants, transport and storage facilities and so on will be needed before imported natural gas could be used on a large scale in Britain.

However, if these obstacles can be overcome and natural gas offered at a competitive price there is a big potential market for it.

World Steel Ownership

Only five per cent of the free world's steel production is nationalised and even this small amount is due to special factors. A survey published by the British Iron and Steel Federation poses the question " why are any steelworks State owned?" Explanations differ from country to country. Britain accounts for more than a quarter of the free world's publicly owned steel. This is almost entirely represented by the few remaining companies whose shares have not been disposed of by the Iron and Steel Holding and Realisation Agency. These companies produce less than one seventh of total United Kingdom output of crude steel. Even so Britain produces more steel in publicly owned mills than any other non-Communist country. Austria's steel industry was nationalised in 1946 to protect it from confiscation by the Soviets. South Africa's main company, ISCOR, is state owned as it was set up at a time when the state was the principal source of capital. The Italian Finsider organisation in which the state has a majority interest was founded in 1937 by Mussolini as part of the Fascist plan to control industry.

Looking ahead, it is probable that the position will change in India where steel is entirely privately owned. On completion of the present development plans in 1960 the much larger capacity then in existence will be owned in equal proportions by the State and private investors. While the non-communist countries have avoided public ownership they have installed various forms of public control. The most elaborate and powerful of these is undoubtedly our own Iron and Steel Board.

State-Owned Steel in Germany

The arguments about who owns the Volkswagen plant have been heard well beyond the German frontiers. It is not often realised however that Germany has a steel and engineering giant in somewhat the same mysterious position.

The Hermann Goering Works at Salzgitter, generally known as the Reichswerke, started production in 1938. After the war the Allies decided to cut it down to one blast furnace and an annual output of 20,000 tons. In March, 1950, the dismantling programme came up against stiff opposition, and after long negotiations it was agreed to stop further demolition. To-day the AG für Berg-und-Huttenbetriebe, to give the Reichswerke its full name, is a flourishing business. The basic reason for starting a plant at Salzgitter—the existence of big deposits of low-grade iron ore—still applies. Now with six blast furnaces production is at the rate of 1·4 million tons a year. A target of 2 million tons a year has been set and this is expected to be hit in the next two years. Salzgitter has now grown into a boom town of 100,000 inhabitants of which nearly half work in the steel plant or its allied industries.

The equipment of the steel works is of course all of the most modern design. It includes a fully automatic rolling mill 650 m long. One of the associated industries is a railway carriage and wagon works operated by Linke-Hoffmann-Busch G.m.b.H. From small beginnings as a wagon-repair shop this has become one of the principal makers of rolling stock both for the German railways and for export. To-day the Reichswerke is one of the giants of German industry. As the biggest state-owned plant of the biggest steel producer in ECSC, the way in which Economic Minister Erhard has apparently been able to use it to influence German steel price levels has given the High Authority at Luxembourg some anxious moments. But whether the various conveniently timed changes that have occurred in Salzgitter prices were engineered by the Minister or just came about through the working of the market is going to be very hard indeed to prove.

Insurance Against Change

Petroleum companies are investing in nuclear energy " at an ever-increasing rate." A recent survey of their investment policy revealed that some of the biggest oil concerns are also uranium miners and refiners. Four of America's top twenty uranium mills are owned by oil producers, as well as eight of thirty-two companies with big radiation research laboratories and seventy-five of the 1,700 users of radioisotopes.

The Texas Company have opened a research centre in Beacon, New York, which is described as " the world's most fully equipped private radiation laboratory." Its 29,100 curies of radioactive cobalt 60 constitutes one of the major sources of radioactive material outside the United States Atomic Energy Commission. Phillips Petroleum, of Dallas, have become a major miller and miner of uranium, with newly erected capacity to process 1,700 tons of ore a day. Other companies, such as Esso Standard, Kerr-McGee Oil Industries, Superior Oil Company of California, and many more have invested in some field of nucleonics. One of the reasons for this development, apart from the wish to hedge against the future development of nuclear energy, is the extensive use the oil industry is making of radioisotopes—for testing and inspection, detection of leaks, measuring of fluid flow, studies of catalysts, and for determining the effects of radiation generally. Seven large oil companies now run radiation laboratories.

Similar hedging action has been taken by some of the shipping companies against the competitive development of air transport, and it is a normal and healthy reaction to change. The danger that this investment by the oil industry should lead to a monopoly-hold on competing materials is not very great in view of the considerable stake of governments in the development of nuclear energy.

US Neglects World Standards

The small tool industry of the United States may find its export market shrinking because the United States is not active in the development of international standards for small tools. This view was put forward by the single American delegate who attended this year's meeting of Technical Committee 29 on Small Tools of the International Organisation for Standardisation in Berlin, Germany.

The United States delegate, Mr. Frank P. Brown, who is chief of Shop Division, National Bureau of Standards, criticised strongly the fact that American industry had taken " virtually no active part in the work of any of the committee's working groups." He argued strongly in favour of United States participation in the work of ISO whose " recommendations " are for voluntary use by member countries as a guide to their own national standards with the aim of unifying the standards of all member countries. Mr. Brown found that " all delegates showed an unusual interest and earnestness in attempting to achieve international agreements on technical problems."

The main message of Mr. Brown to United States manufacturers was that adoption of ISO standards which differed from American standards would diminish their export market. On the other hand, more active participation could stimulate their sales abroad and would certainly promote " a better understanding of the American viewpoint " among other nations. Noting that at the present time there is a strong pressure to use only metric units. Mr. Brown suggested that the United States " could lend weight to the efforts aimed at incorporating English measurement units in international standards for small tools."

Letters to the Editor

SHAW'S ALPHABET

SIR, Plain Words, in your issue of 12 September, rightly commends Shaw's attempt to provide for the English-speaking world a new alphabet to be designed to suit actual conditions. It also correctly assesses the engineer as a man with a mind more open to the revolutionary idea involved than is the Arts graduate, and as one probably effective as a designer. Above all, Plain Words was right to " implore you to get those papers from the Public Trustee and examine the whole thing for yourself."

It is a fascinating challenge to a designer. The pre-determined conditions—at least 40 letters and only one form for each—are the limitations which any engineer understands: they correspond to those of the width of the chasm to be bridged and the weight the design needs to carry. The whole of the rest of the field is, however, open and free to the designer.

Fortunately, Dr. Godfrey Dewey in his *Relativ Frequency of English Speech Sounds*, (Harvard University Press, 1950) has tabulated on a 40-sound basis (Table 18) and on a 41 + 1-sound basis (Table 17) the percentage frequencies of the sounds of the English language as exemplified in print; also the percentage frequencies of each of the 26 letters now used in written and printed English (Table D1): the designer has thus at his disposal the factual background for the allocation of his letters to sounds.

But the question of legibility and beauty of alphabetic forms has not yet been studied. Some work has been done by Legros and Grant, but only within the Roman alphabet and only to indicate principles whereby the relative merits of, say, A a and *a*, or various minor variants of each of them, may be assessed: no studies have yet been made to compare Roman with Arabic, Cyrillic, Devanagari and Tamil—to mention only some of the very different alphabets now in current use—or with one another, in order to establish what are the factors which contribute to legibility and beauty, and to what extent these two features of an alphabet are complementary, or antithetical, to each other.

In the absence of such information, I can only suggest, as some of the important points to be borne in mind, that what is described as the x-ribbon (the two middle lines in lower-case " a b p x," and the only two lines in upper-case " A B X ") is most important; that the ascenders of " b d f h l, etc." ought possibly to be more frequent than the descenders of " p, etc."; and that it is possible that ascenders and descenders such as " f and g " (which use the horizontal dimension as well as the vertical one) are more legible than those which use only a straight vertical as " h l p, etc."

The 10 Arabic numerals " 0 " to " 9 " are clearly, by accepting the predetermined condition that they shall be 10 and have only one form for each number, better than the Roman numerals with their virtually only two units " I " and " V " and their alternative forms " IV " and " IIII." Moreover, Arabic numerals have five descenders and two ascenders in many founts, and where they do ascend or descend the main body of the numeral is within the x-ribbon, thus: 0 1 2 3 4 5 6 7 8 9.

What conclusions ought to be drawn by a designer—and by the Public Trustee and his advisers—in the choice of the forms for the 40 sounds? It will no doubt be difficult to judge between the different new alphabets submitted, but it will be surprising indeed if all of such new alphabets will not be better than is the existing Roman one, seeing that the new alphabet will have been deliberately designed for its purpose in use—namely, only one alphabet for the printing and writing in millions of letters every second of the day on paper for easy communication of the English language, whereas the three existing Roman alphabets have come to us fully developed for their original purpose, namely the

Continuing Letters to the Editor

carving of letters very occasionally on stone for display on ceremonial occasions of the Latin language.

Whether, and to what extent, men will use the better tool when designed is a question which faces every designer—but it has never yet been a justification for not designing that which could be better. For myself, I note that two revolutionary new human accomplishments for communication, shorthand and typewriting, have spread through the world—and only because of the human need and their merits. I see no reason why, in time, Shaw's tool, if better, should not follow the example of Arabic numerals and be used in parallel with, but in overwhelming paramountcy over, the existing upper-case, lower-case and cursive variants of the 2,000-year-old Trajan lettering.

Yours faithfully, I. J. PITMAN.

House of Commons, London, S.W.1.
18 September, 1958.

REPRODUCING RADIOGRAPHS

SIR, As an industrial radiologist with some knowledge of weld radiography I found the illustrations in your article, " Reducing Worm Holes in Welded Pipe Joints," somewhat difficult to follow. (ENGINEERING, 15 August, page 223).

I would go so far, in fact, as to question whether the illustrations were radiographs as stated. From a careful examination it appears that these are " positive " prints made by printing directly from the radiographs on to bromide paper. If this is so, there is obviously a complete reversal of tones, and cavities which appear as dark or black marks on the radiograph are shown light or white on your reproductions.

To reproduce any form of transparency on paper is difficult, and radiographs are the most difficult type of transparency to reproduce. This is due to the inherent high contrast of radiographs, of which the brightness range may easily be in the order of 1,000 to 1. This range has to be reproduced on paper which has a brightness range of some 50 to 1. From this, it will be seen that it is practically impossible to print radiographs directly on to bromide paper, even if one is prepared to accept the tonal reversal.

The accompanying print from a radiograph shows that it is possible to reproduce a radiograph on paper in a fairly satisfactory manner, and I intend sending you in the near future an article describing methods which can be employed.

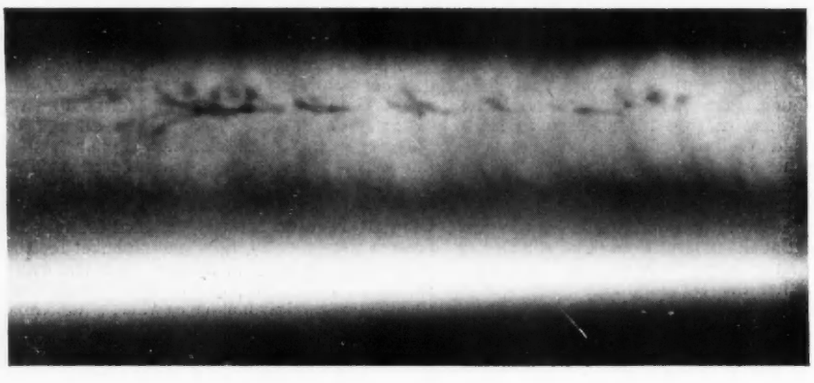
The weld shown contains piping which not only conforms to the definition, " an elongated or tubular cavity due to entrapped gas," but also shows the " herring-bone " pattern to which the text-books so frequently refer but which is not often seen in practice.

Yours faithfully,

R. O. COUCHMAN,
Chief Radiologist.

Kent Alloys Limited,
Rochester, Kent.
24 September, 1958.

A section of a circumferential weld taken with a 150 kV rod anode unit, showing piping.



RETORT TO RED ELEPHANT

SIR, I was interested to read your comments in ENGINEERING for 19 September from London Transport. I have not had the opportunity of reading the full reply of London Transport to the comments made in my paper at Blackpool, but I would draw attention to one point in the LTE reply, which states that " over 250,000 people are transported by the undertaking's road vehicles between 7 and 10 a.m." This figure has also appeared in other papers. As the total passengers carried by buses, coaches and trolley buses for 1957 were given in London Transport's annual report as 3,182,000,000, which is something approaching 9 million passengers a day, I can only suggest that either London Transport's concern for accuracy has failed in this instance, or else the fall in traffic in London has been far heavier than anyone anticipated!

As far as my paper is concerned, I stand by every word.

Yours faithfully,
NORMAN MORTON,
General Manager and Engineer.

Transport Department,
County Borough of Sunderland,
Monkwearmouth, Sunderland.
26 September, 1958.

QUESTIONS OF DEFINITION

SIR, Professor Saunders is surprised that some people find difficulty in giving a satisfactory answer to the question " What is heat? " (" Heat and the Engineer," ENGRG., 19 Sep. '58, p. 383).

I wonder how many engineers can give a crystal clear answer to the following questions:—

What is electricity?
What is magnetism?
What is plasma?
What is a metal?

The last question ought to be easy to an engineer but I have never found one that could give a really unassailable answer to it. Perhaps the modern atomic physics people have now got such an answer and to the three earlier questions also.

Yours truly,
S. H. RENDELL.

44 South Hill,
Manningtree, Essex.
27 September, 1958.

STRAIN HARDENING OF CYLINDERS

SIR, Dr. E. Voce, in his letter (ENGINEERING, 19 September, p. 363), seems to regard the early part of the yield process in a thick-walled cylinder subjected to internal pressure as similar to the gradual spread of plasticity in, for instance, a tension test. There is, of course, no similarity in these two cases, as in tension the material is uniformly stressed and when it yields there may be a gradual spread of yielding throughout the material, either at constant stress or gradually increasing stress, depending on the material. Whereas, in a thick-walled cylinder, the stresses are not uniform through the wall thickness, and when the stresses at the bore are sufficient to cause yielding the stress at the outer surface will be considerably less. Consequently, even if the material yields at constant stress, the equilibrium pressure will rise as the yield spreads concentrically throughout the cylinder wall. Though Dr. Voce ignores this region of small plastic strains it is a region of considerable technological interest, for example, in the design of autofrettaged cylinders.

With regard to the comparison of tensile and shear strains, there are any number of arbitrary definitions, such as that suggested by Dr. Voce, which would satisfy the conditions of constancy of volume. In these circumstances, it seems sensible to accept the particular definition which also satisfies the hypothesis that strain hardening is some function of the work of plastic deformation, which is not altogether unreasonable. This latter hypothesis has found wide acceptance and, until it is disproved or some better hypothesis is suggested, I think we should not lightly accept any of the many alternative possibilities.

Yours faithfully,
B. CROSSLAND,
Senior Lecturer.

Mechanical Engineering Department,
The University, Bristol, 8.
27 September, 1958.

MORE FOR THE CONSUMER

Spending on consumer durables, that is cars, refrigerators, washing machines, television sets, furniture and so on, fluctuates more rapidly than any other kind of spending. Also more of these items than any others are bought on credit. Between 1950 and 1957 the volume of new durable consumer goods sold in Britain increased by 64 per cent, while all other personal consumption went up by only 14 per cent.

Since 1950 considerable changes have also taken place in other countries. According to OEEC estimates given in the Treasury's *Bulletin for Industry*, British spending on consumer durables in 1950 was only 24 per cent of that in the United States. In France the corresponding figure was 15 per cent, in Germany 13 per cent, and in Italy 2 per cent. Since 1950 this expenditure has been increasing faster than the rest of personal consumption in the United Kingdom and in Western Europe generally, but not in the United States.

Statistics of total personal spending in the United Kingdom show a rise of 14 per cent at constant prices between 1950 and 1957. In the same period spending on all consumer durables rose by 64 per cent. Inside this total, spending on furniture and floor coverings rose by 20 per cent, on radio and electrical goods by 62 per cent. and on cars and motor cycles by 277 per cent. Although consumer durables have taken a bigger share in the increased personal expenditure over the past seven years they have also fluctuated more widely. Perhaps the new regime of easier credit will do something towards evening out these variations in buying habits.

SCHOOLS AND INDUSTRY

A conference on " The Link Between Schools and Industry " is to be held at Cheltenham Town Hall on 21 and 22 of this month. Papers presented will deal with what Gloucestershire schools have to offer industry and with new technological developments. An exhibition on " Opportunities in Engineering " will be held in the Imperial Gardens, Cheltenham, on 21 to 25 October. Both are sponsored by the Gloucestershire Industrial Education Council, Cheltenham.

Plant and Equipment

DICTATION MACHINE

The Agavox dictating machine can be controlled from the microphone or even over a telephone circuit.

An improved version of the Agavox dictating machine is to be shown at the Business Efficiency Exhibition held recently in Manchester. Made by the Aga Dictating Machine Company, St. Stephens House, Westminster, London, S.W.1, it is shown in the accompanying illustration. The model C has a new microphone, simpler controls and better facilities for telephone recording.

The microphone has three controls: record/playback; start/stop; and jump back. These enable the machine to be operated entirely from the microphone. A red light gives warning when the switch is in the record position. The jump back switch enables the dictator to go back to any point, and is not limited to the last phrase or sentence. Both sides of a telephone conversation can be recorded by plugging in the attachment and depressing a switch.

Like the earlier models, model C uses six or twelve small plastics discs which have a minimum life of 20,000 recordings. The discs are slipped into a slot, and a paper index strip shows by punched pin holes the number and length of letters and the position of any corrections. Corrections can also be made by "speaking over" the recording. Playback can be over a built-in loudspeaker or a microphone, at will. For transcription there is a choice of three playback speeds and the machine can be operated either by hand control or by foot switch.

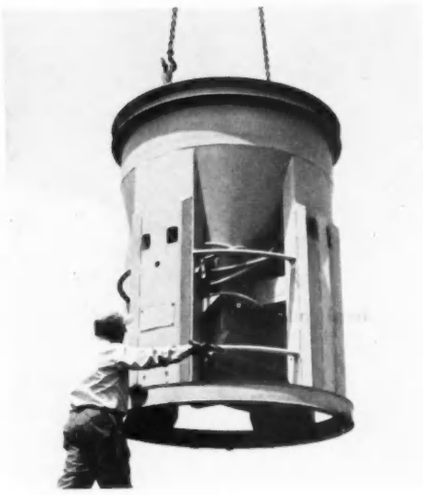
For use with the dictating machines is a system called Teledictation. This can be operated through separate wiring or through an existing house telephone installation. It provides dictation facilities for every telephone in the installation and also control of the dictating machine for recording, playback or correction.

AUTOMATICALLY DISCHARGING BUCKET

No external source of power is needed to operate the hydraulic mechanism that opens and closes the discharge doors of a 4 cu. yd concrete transport bucket made by the Blaw-Knox Company, 300 Sixth Avenue, Pittsburgh, 22, Pa., USA, and shown in the illustration. The weight of the concrete itself provides the force needed.

This result is obtained by suspending the bucket on two hydraulic cylinders so that the weight is transmitted to the working fluid in them. The operator then has only to turn a hydraulic valve to allow fluid under pressure to pass to the door-opening mechanism. Releasing the valve closes the doors. Each time the bucket is set down on the ground, the fluid flows back into the cylinders so that they are ready charged for the next lift. This occurs naturally when the bucket is returned for refilling.

As an alternative to the hand operation the bucket can be equipped with a remote radio control system so that the operator can stand 75 or 100 ft away from the point of discharge and open or close the doors at will.



The weight of the concrete in this 4 cu. yd bucket supplies the power for working the discharge doors.

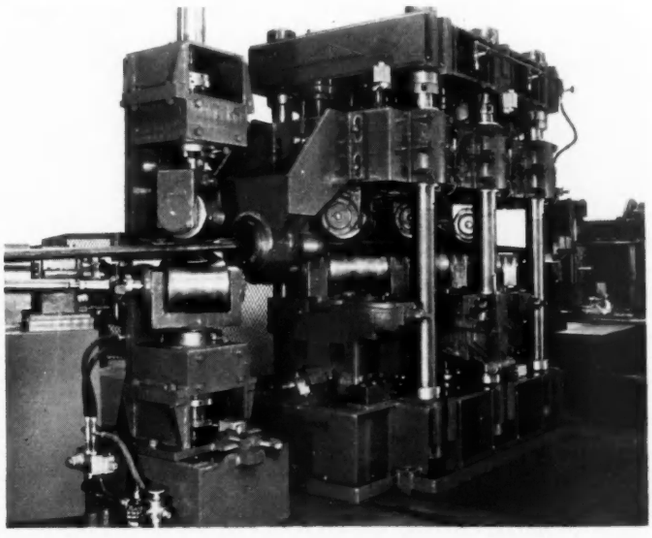
PNEUMATIC SCREW DRIVER

The latest addition to the range of tools made by Desoutter Brothers Limited, The Hyde, Hendon, London, N.W.9, is a pneumatic screw driver or nutrunner with a capacity of $\frac{5}{16}$ in. It is driven by their SR50 motor. The tool incorporates a spring loaded clutch that can be adjusted to give the required tension to the screw or nut. The weight is 4 lb and the free speed is 500 r.p.m.

TUBE STRAIGHTENING

The latest addition to the range of bar and tube straighteners made by Joshua Bigwood and Son Limited, Wolverhampton, is illustrated herewith. It is a multi-roll machine with three pairs of rolls, one roll of each pair being above and one below the material pass line. All the rolls are driven.

As illustrated, the machine has been designed for straightening tubes from $\frac{1}{2}$ in to 3 in diameter and from 29 s.w.g. (0·0136 in) to $\frac{5}{16}$ in wall thickness, in high and low carbon and stainless steels, copper, brass and light alloys. It is particularly suitable for applications where precision in straightening, correction of ovality and good surface finish are important. Bars can also be straightened.



Precision straightening, correction of tube ovality and high class finish are characteristics of the Bigwood multi-roll straightener with all rolls powered.

The machine has a base and entablature of fabricated steel, connected by heavy round steel bars, which are machined and ground to form slideways for vertical adjustment of the brackets for the three top rolls and the middle bottom roll. All the rolls are angularly adjustable, and the two outer bottom roll brackets are mounted on slideways on the base, so that the rolls can be adjusted inwards or outwards along the pass line. Independent vertical adjustment of the outer top rolls and the centre pair of rolls is by means of three geared motors. The centre rolls may be moved in unison, or the top one can be adjusted independently, by using a clutch. Scales are provided to show the lateral and angular adjustments of the rolls.

Two variable speed motors, each coupled to a separate gearbox on fabricated steel baseplates, drive the straightening rolls through universal couplings. One motor drives the top set of rolls and the other the bottom set. Driving all the straightening rolls eliminates roll skid, and this, coupled with accurately ground roll contours, the lack of inter-roll guides and rigid general construction enables the required high standard of straightness and surface finish to be obtained, even on very thin-walled tubes.

A powered feed roll arrangement is provided to operate in conjunction with the user's feeding equipment.

Special Article

Talk of the Town's Technical College

As more reports on the national problem of technical education appear, the technical college seems to lose its personality. The greater the outflow from committees and conferences, the deeper the individual college becomes submerged in statistics and generalities. Yet each college is still very much a part of its locality and needs local co-operation for success; where co-operation has not yet developed as much as could be hoped, it is mainly because too little is known of the aims of the college. This article describes four—Norwood Technical College, Royal Technical College Salford, Reading Technical College, and The College, Swindon—and puts forward some of the problems facing members of their staff, as discussed in conversations with our representative.

" Technical colleges have grown up in response to local demand, their siting being largely dictated by the location of industry," points out the 1956 White Paper on technical education. And this is basically true. As a result, technical colleges have tighter links with their town than have schools or universities. A school takes pupils in a fixed age group and they learn the same sort of things wherever they are in the country. Pupils do not decide the set of subjects studied at school. But a technical college opens its doors to people of all ages, and teaches them what they want to know. It has to keep its eye on technical change in its area and be ready to put on new courses. It gives local industry the skills it asks for.

But exceptions to the pattern can soon be found. Colleges are now responding to national as well as local demands. More are developing national reputations—for example, Norwood for its radio courses. Some become colleges of advanced technology, Salford is an example, and their national aspect gains importance; the response is no longer solely to local demand.

As far as the actual siting is concerned, the technical college is very much part of the town. It stands on a main road, with its door close to the pavement. A bus stop will be nearby; generally it is within easy reach of a railway station.

Suppose you arrive at West Norwood station: little reason to stop there. Go out along the road, past a vacuum cleaner factory in a yellow cinema, past the usual chain of suburban shops—bottled beer and groceries; Charley's dinners; stationers, fruiterers, a wool shop—then past a garage and up a hill. Knight's Hill: houses reach up its sides and at the top Norwood Technical College stands. The architecture is curious. On to a churchlike building is joined a building in 1939 educational redbrick; the junction is by means of a " bridge," in contemporary curtain-wall architecture, carrying a corridor and several rooms. The same style is displayed by a building grafted on to the far end of the 1939 building. On top of the last addition a radar aerial rotates.

You approach through the local environment. Swindon is different. Leave the station, situated in the old town, which grew up around the railway works, and follow the narrow road that serves as High Street. Skirt the clock-towered town hall and library, pass a brewer's poster bearing a picture of a bottle (12 times full size) between two locomotives (somewhat reduced), and see the Trinity Presbyterian Church. In front of it runs Victoria Road. This slopes up to the new town—once chiefly a residential area for senior railway officials. Part of the way up the hill, houses give way to a large three-storey building in redbrick: Swindon Technical College, behind grass slope and clipped privet.

If there is such a thing as a typical technical college building, Swindon would seem to have it. Construction was finished in 1896, and it is of excellent design for its age. About this time many colleges were built. The number in fact caused the Editor of this journal some concern, and he wrote (ENGRG., vol. 62, p. 341, 1896):

" Some eight or nine years ago that excellent gentleman Mr. John Bull made a great and startling discovery . . . he awoke one afternoon to the fact that his dividends were less substantial than they ought to be, and that foreign firms, if they had not succeeded in diminishing his turnover, had at any rate very substantially affected his rate of profit.

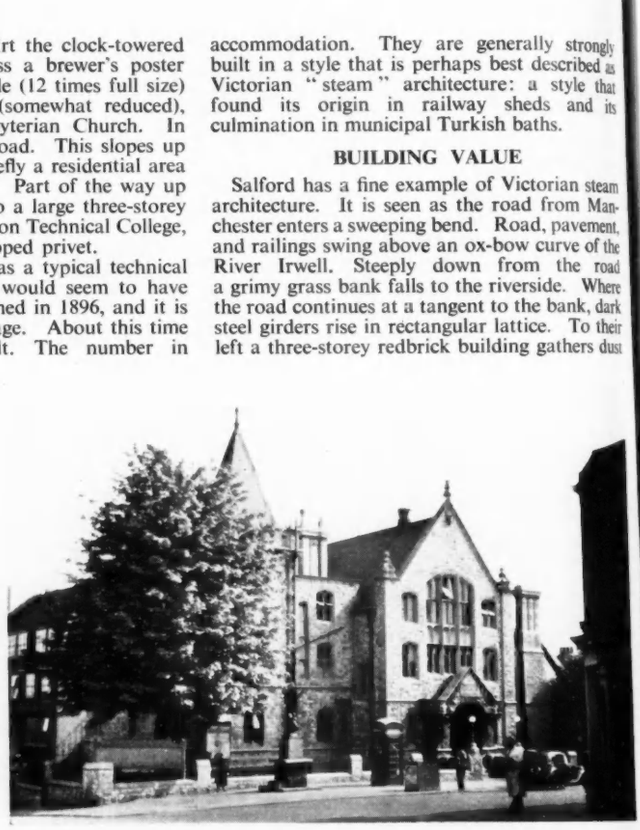
" After a survey of the whole situation, Mr. Bull decided that he must have technical education, and he determined to outdo his competitors, in quantity if not in quality . . . technical institutions arose like magic throughout the country, and were in aggregate heavily endowed with imperial and local resources."

Sir Philip Magnus, writing a little earlier, was able to remark, " Other circumstances resulting mainly from the application of steam power to machinery have rendered technical education necessary." Now other circumstances have rendered it even more necessary.

The technical institutions that " arose like magic " at the turn of the century still form the major part of present-day technical college accommodation. They are generally strongly built in a style that is perhaps best described as Victorian " steam " architecture: a style that found its origin in railway sheds and its culmination in municipal Turkish baths.

BUILDING VALUE

Salford has a fine example of Victorian steam architecture. It is seen as the road from Manchester enters a sweeping bend. Road, pavement, and railings swing above an ox-bow curve of the River Irwell. Steeply down from the road a grimy grass bank falls to the riverside. Where the road continues at a tangent to the bank, dark steel girders rise in rectangular lattice. To their left a three-storey redbrick building gathers dust on its black slate roof, its towers, and its many chimney pots. Salford Royal Technical College.



The 1859 end of Norwood Technical College serves as a reminder of the age of some of the buildings used for technical education.

". . . the Government have decided on a further expansion of technical colleges. . . . This will call for building to be started in the period 1956-61 to the value of about £70 million," stated the White Paper, and at Salford the expansion is to be seen in progress. How valuable a good building is can be illustrated by the experience at Reading.

In 1950 the classes were held in 22 separate buildings. To put it mildly, the conditions made organisation difficult. But the damaging effect is that the college becomes little more than a name-plate on a house. Except for the enterprise of the staff, the college might have been neglected by local industry—any one of the many buildings used gave little indication of the scope of the college, while the approach of a firm to the college with the suggestion of a new course might well be fruitless through lack of space to accommodate it. Reading needed a new college building.

It got one. The new building was large compared with the known demand. The developments that followed were interesting. It was possible for any passer-by to see that the

college meant business, for the new building inspired confidence; local firms had visible evidence of the equipment available to give students technical education. This, together with the pains taken by the college to make its plans known, made it clear that releasing trainees during working hours was worthwhile. Day release classes gained students rapidly, as did the other types of class. An idea of the rate of expansion of the college when it acquired its building is to be seen from the graph overleaf. Not only does the graph indicate the increase in students that has taken place, it also suggests that more and more students will go on entering the college. Lack of space is already a serious problem at Reading.

At Swindon, the first request for an extension was made about thirty years ago. Now the college is to have a new building costing £380,000; to make room for it 50 houses and a church have been demolished. At present, apart from the main building, other premises have to be used. Behind the block facing the road is what one frequent visitor to the college refers to as the "workhouse block"; it is soon to be pulled down. "Fancy designing this building as a school," commented Mr. Gillespie, the Principal, as he walked through it with our representative. "You can hardly believe it, can you?"

Behind the building is a collection of sheds, provoking the comment, "a shambles of a place, don't you think?" But good use has been made of these buildings: there is a respectable range of machine tools there. Much of the equipment, including a two-dimensional wind tunnel, a cutting-tool dynamometer, and a sectioned gearbox, has been produced by the staff. "I don't believe in buying equipment for the college: I only buy things I can't make,"

THE COLLEGES AND THEIR PRINCIPALS

Norwood Technical College, West Norwood, London, S.E.27.	*H. V. Hillman, B.Sc., M.A., F.R.I.C.*
Reading Technical College, Reading, Berkshire.	*J. Dimmick, B.Sc., F.R.I.C.*
Royal Technical College, Salford 5, Lancashire.	*C. Whitworth, M.Sc., Ph.D., F.R.I.C., F.Inst.F.*
The College, Swindon, Wiltshire.	*W. Gillespie, M.Eng., B.Sc.(Eng.), M.I.Mech.E., M.I.Prod.E., A.F.R.Ae.S., A.M.I.Mar.E.*

explained Mr. Gillespie. "You've got to be canny on this job; never buy what you can beg. We don't buy new files—we send the old ones to be recut in the workshops of one of the local firms. You can recut a file about four times.

"We've used some pretty ropy old places for classes," continued Mr. Gillespie, "ends of corridors, store rooms, and so on. We reach about peak load at day time, but we have the safety valve of the annexe at the top of the hill. That would give us about ten more rooms. It's a poor college that turns a student away because of lack of room." There was a break in the conversation while the principal settled a difficulty that had arisen in the installation of a steaming oven. Then he outlined the plans for expansion:

"The new building is six storeys. Then we'll get a library, reasonable suite of offices, and laboratories. There'll be about 6,000 sq. ft of teaching space. The library in the college is in bits and pieces at present. We have no librarian. But we work in conjunction with Borough Librarian—the library across the road, it's very useful."

Charles Pike, the architect for the new extension at Swindon, is faced with a recurrent problem in the present technical college expansion programme: how to join a contemporary building on to one that is 60 years old. His solution is shown in the illustration on the next page.

As for the design inside the building—that becomes a problem that the principal and the architect have to spend a lot of time over. The stamp of the principal's mind is on any new technical college. It is he who is on hand to point out that, if the machine shop is widened by a few feet, then they can fit three rows of machines in and use the space economically, rather than have two rows of machines and waste a lot of space. He points out how the flow of students from room to room during the day and evening must decide the different uses appointed to the various floors. He decides whether it is best to have the staff rooms on the ground floor or up under the roof; which is the best way round to have the benches in the laboratories; the different types of lighting needed in the various departments; how much room for the office staff; and so on, and so on.

At Reading the result of the process can be seen; at Swindon it is just starting; at Salford a new principal is faced with the fact that the new building, already complete in its early stages, was originally designed for different work from that which it is going to be used for. At Norwood space is short and a further extension would be welcomed; but till it becomes possible, the staff are able to study the results of three different views of how a technical college should be constructed.

LINKS WITH THE TOWN

Mr. Gillespie was going to visit Reading: "Come and have a look round so you can avoid making the mistakes I did," invited Mr. Dimmick. But there are not many: Reading Technical College is well designed. The generously equipped machine and workshops, for example, are well laid out and have the appearance of a modern factory department. The main entrance, set back behind a flagged path and grass lawns, has an academic look; but the doors in the wings provide direct access to the pavement. The usual bus stop is close by. Two notice boards flanking the main entrance tell the passer-by of activities in the college: there is to be a series of lectures on education in Reading, a lecturer from Paris is to describe the *Citè Technique* and the French system of further education. There will be a student dance.

Links with the town: many people are interested in local education; parents, for their children (or even for themselves), local employees, and local employers; a picture of facilities is of value to them. But there is not the understanding that could be hoped for of how the technical college fits into the scheme of local education. This was pointed out at the Windsor Conference on Industry and the Technical Colleges. There a managing director was able to say that after he had written to three headmasters of grammar schools about the liaison that existed between each school and its local technical college, "All three of them replied at considerable length, and all three were unanimous on the fact that they knew very little about technical colleges. Occasionally, they were proud to report, one of their boys had gone to Loughborough and another had gone to Battersea Polytechnic; but that was about as far as it had got. They knew very little of their local technical colleges. They felt vaguely that there was something they could pass their people to, but

Reading Technical College is fortunate in having a modern building to house all its facilities; not many colleges are so well equipped.

Continuing Talk of the Town's Technical College

they had not really got the contact there that was desirable or necessary."

Part of the blame must lie with the technical colleges themselves. Many of them do not keep their activities before the eyes of the local people. The lectures on education at Reading were one way of showing the part played by the technical colleges—explicitly by the lecture itself, implicitly by the fact that the lecture was put on by the college. Also Reading had a building that people would be glad to be invited to.

There are other ways. Norwood Technical College co-ordinated the observations made on the first Russian earth satellite by amateur radio enthusiasts. The radio and telecommunications department there has an interest in radio astronomy; it quickly saw that amateur readings would be of value. The organisation the department carried out came to the notice of the local Press who made it headline news on their front page. In this way, it was possible for people in the neighbourhood to see that the college was alive and aware of technical developments. Much of the credit must go to the journalist who discovered the story; but for him the college's activity would have gone unnoticed except by the few people directly concerned. Now interest has been created and there are likely to be further articles in the local paper about the college's interest in radio astronomy.

At Swindon, lectures on such things as Automation, and Human Relations in Industry make it well known to industry in the area. Mr. Gillespie explained how he went about making the lectures a success. "Write to firms and everybody you can think of. Give up handbills—contacts are far better. Ask them first if they are interested and if so how many they will send along. When they let you know the number ask them who they are going to send. Then get a manager of a local firm to take the chair at the meeting." By rousing people's interest in the work of the college, it becomes possible to build up co-operation. "Get them into the college—that's what you've got to do. Then you get something out of them. You've got to be a bit cheeky in this game to get away with it."

Co-operation is important in Swindon because the town, perhaps to a greater extent than any of the others visited, is passing through a transition period. Not only is the population growing rapidly but the industrial scene also is changing. The college has to keep up with the changing demand.

"Years ago it was all railway work," explained Mr. Gillespie. "Now there are a lot of new firms here: The trend is towards new light industries . . . At one time the railway owned one or two schools; the railway ran the library; it ran the swimming baths. The chief engineer of the railway works would be in charge of 50,000 people. The needs were based largely on the needs of the railway worker.

"But now it's changed. There are the new firms here; with the town expanding, there is a demand for builders; and people on military service at camps nearby come here.

"We try and visit firms regularly. A member of staff has recently spent a week at a local firm's laboratories. If you're short of a teacher you can ring up the works manager, who makes it almost an order. All firms are very co-operative: they help us any way they can. I don't think there's a bad employer around here to get on with. You've got to ask the right man, of course.

"There are about 1,000 students who are released during the day from their firms for part time courses. It certainly could be a lot higher. Building up to 18 is good. The railway doesn't give it for the first year their apprentices are with them. The newer firms are just as good in releasing apprentices as anywhere else in the country. The railway has a lot more apprentices than attend classes; railway carriage and wagon construction are not heavily supported. There are a lot of builders and plumbers in the railway but they don't come to part time day courses.

"The chief difficulty is obtaining a quick decision, because of the size of the organisation. Actually, day release was granted in selected cases by the GWR many years before it was granted in most firms, and the college was mainly built due to GWR influence 60 years ago."

TABLE I

Advisory Committee, Department of Engineering, Reading Technical College

A. G. Beverstock, Ph.D., M.A., A.M.I.E.E., A.Inst.P.	Education and Training Officer, Southern Electricity Board.
L. J. Bradley, A.M.I.Plant E.	Trades Council
E. S. Cornell, M.Sc.	Head of Alfred Sutton School (Local secondary school with technical bias)
C. J. Ferguson, M.I.Mech.E., M.I.Prod.E.	Fairey Aviation Company Limited
J. A. C. Gibb, M.A., M.Sc.	Agricultural Engineering Department, University of Reading
F. L. Gordon	Personnel Manager, Huntley, Boorne and Stevens Limited Member of local productivity association
A. H. Greenham, M.A., A.M.I.C.E., A.M.I.W.E.	Howard Humphries Limited
R. J. Harley, B.Sc. (Eng.), A.M.I.E.E.	Basingstoke Technical College
R. G. Henbest, A.M.I.E.E., A.M.Inst.F.	Superintendent, Earley Power Station
J. R. Knox, M.I.Mech.E., M.I.Agric.E.	Technical Director, Gascoignes (Reading), Limited Member of Chamber of Commerce
A. J. Lee	Trades Council, Electrical Trades Union
R. E. Mannings	Youth Employment Officer
J. R. Privet	Managing Director, Transport Equipment Limited, Reading
Councillor F. Taylor	Reading Education Committee
C. C. Thiel, Ph.D.	National Institute for Research in Dairying
R. Townson, B.A.	Member of staff training division, Atomic Weapons Research Establishments
E. W. Weaver, A.M.I.E.E.	Telephone Manager, member of local productivity association
A. W. Woodbridge, O.B.E., M.Sc., A.C.G.I., D.I.C., M.I.E.E., M.I.R.S.E.	Signal Engineer, British Railways, Western Region
P. E. Hawes, B.Sc.(Eng.), M.I.Mech.E.	Head of the Department of Engineering, Reading

An extension to the 1896 building at Swindon will help to meet the demand for technical education in a rapidly expanding community.

COMMITTEES AND COMMITTEES

The value of local contacts was also emphasised by Mr. Dimmick, Principal of Reading Technical College. "At an early stage we set up advisory committees for all departments; on these the industrial representation is very strong indeed." Most colleges, in fact, have advisory committees but the attitude to them varies from college to college. There is no standard. At Reading the members of the committees are all appointed by the Governors; Mr. Dimmick explained "they are not nominated and do not directly represent organisations. They are chosen as the most suitable to give advice over the whole field.

"I send out information about the committee very widely, particularly to industry, inviting suggestions. The Governors of the college make appointments from the suggestions that are put in." To give an idea of the composition of the committee that results, the one for the engineering department is shown below.

But committees and representatives have not been the only influences on the programme at Reading. Mr. Hawes, head of the department of engineering pointed out that students themselves could have their effect. "In 1952 three fellows from the Post Office enquired whether they could take a course in electrical engineering. There was, at that time, little evidence to suggest strong demand in this field; but we decided to test this. The original course developed into years 1 and 2 of an Ordinary National scheme, but it seemed very doubtful whether Higher National electrical engineering would be required in Reading. In fact we made arrangements with Oxford Technical College for a contributory scheme—the students were to go to Oxford for their third year. Later we found there were more than enough to make up the class. And they were keen too. At the end of the second year they came and asked "What about it. Can we stop the next year at Reading?" After Regional discussions, a third year was arranged —in Reading. And the course did not finish at Ordinary level. It went on. They reached their final exam for the IEE in 1956. Since then one has become an associate member of his institution, and a strong flow-through is clearly developing.

"I think it has been a remarkable example of co-operation between students and staff, it shows what can be done when we all pull together. There is now quite a lot of work done in electrical engineering at the college; but the initial stimulus came from that group of students".

Swindon does not have a board of governors in the same sense that other colleges do. The governors are Swindon Further Education Committee. They are advised by committees for each department, but some of the local industrial firms requested representation on the board of governors. Actually, any one can write in for representation but the further education committee discusses many other things besides the college; so the practical solution was arrived at whereby an overall advisory committee for the college was formed with strong industrial representation.

Norwood Technical College adopts a different attitude. Its advisory committee to the department of telecommunications engineering is shown in the table, and it will be seen that it has something of a national character. The department

relies a great deal on its contacts with the electronics industry throughout the country rather than solely on local firms.

"Broadly speaking," said Mr. Danielson, head of the department, "the local electronics industry isn't the type likely to take many of our students. Most of our contacts are with firms or corporations some distance away.

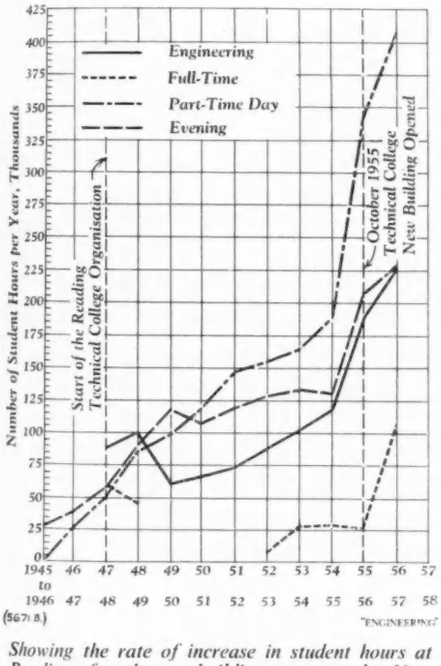
"Classes of students visit about thirty of these places during the year—usually two members of staff go along with them. Visits are made, for instance, to such firms at Marconi's at Chelmsford, Pye at Cambridge and British Timken at Northampton; and to operational stations as well, BBC and Post Office stations, places like Rugby, Daventry, North Foreland.

"In addition, there are contacts kept up by individual members of staff, including myself, when they visit industry, research stations, and so on—talking over new techniques, or proposals for new courses. These often give rise to return visits to the College. Naturally such activities take up time but they're certainly rewarding.

"We have a departmental advisory committee, which up to about three years ago seldom met. Now it meets regularly, once a year. The Governors rely a lot on its advice about proposals put forward by the department."

The students themselves sometimes travel considerable distances—a number from places like Eastbourne, Southend, Worthing, often travel to and from the College each day; others from further afield—the Midlands and West Country, for instance—live in digs.

Norwood also has a large number of overseas students, mainly in the courses for the General Certificate of Education. Of the 128 students in



Showing the rate of increase in student hours at Reading after the new building was opened. Note that the curve does not show any marked tendency to flatten off.

the Ordinary level courses, 97 were from overseas, 26 nationalities being represented. In the Advanced level courses, 150 out of 200 were overseas students.

And in the north, Salford too is developing a more national aspect. When the new building is finished it will house the College of Advanced Technology only; the old building will be a separate "feeder" college, giving tuition at a lower level. The departmental advisory committees are set up by the governing body of the college, which decides the organisations that should be represented, while the organisations themselves select the man. "Co-operation with local industry is very good," said Dr. Whitworth, the Principal. "During the day, engineering firms let staff off for teaching. And the college allows lecturers time off to visit firms. There is almost a free trade between industry and the college." The desirability of such co-operation is emphasised in the 1956 report on "The Supply and Training of Teachers for Technical Colleges." The chairman of the committee that prepared the report was Sir Willis Jackson, director of research and education, Metropolitan-Vickers Electrical Company Limited, nearby at Trafford Park. This would appear to account to some extent for the ready co-operation of industry that Salford enjoys.

THE STAFF MAP

Dr. Whitworth gave the visit of a lecturer to Pilkington's Glass Works as a typical example of the day or two-day visits that lecturers can make in order to keep in touch with technical developments. "There's a growing freedom," he explained. "We are quite prepared to consider requests from a lecturer to go into an industry for six months, without loss of pay.

"Such requests are, however, difficult to grant when a college is short of staff. The absence of one member puts an increased burden on the others." And it seems that the North is the area that suffers most from a shortage of staff.

At Reading there was no urgent staff problem two years ago. "But," pointed out Mr. Dimmick, "it is now much more difficult, particularly at higher levels. There is as big a problem in respect of laboratory and workshop technicians." Mr. Hawes, head of the department of engineering, agreed with this. "It is a very serious problem in my department. For technical posts we need men with considerable craft skill—but that alone is not enough. They must also have personal qualities which promote sound relationships with the student body and good teamwork with the teaching staff."

At Swindon too there is no serious lack of teaching staff. Although the town is expanding rapidly—30,000 people, mostly young families, are to be added to the population—Mr. Gillespie did not expect a staff problem: "I should say we'll have the staff. We are starting to build up now. I think the staff problem is not so bad here as it is in the North. A man from the industrial north thinks Swindon is a lovely place. Up in the North the trouble is not the pay but the country. If you want a better job you must go to an industrial area, which is not attractive. I can walk home to lunch, which is something worth doing."

Dr. Whitworth agreed with this point of view. "It is harder here to get suitable men. Perhaps this is due to the climate. And there is no real financial inducement in many cases. A position in this district having a salary £100 above a London post offers, in effect, about £35, because moving north would mean a loss of London allowance. Why uproot a family for that?

"We are about 10 per cent short of the number of teachers we need. The most difficult subjects to fill are those on the mechanical engineering side. Industry always has the advantage. It may not pay a higher salary in general, in fact college salaries compare very favourably with industry now, but it can always overbid us for the exceptional man. It is the exceptional man we are looking for."

PROBLEMS OF SPACE

There is not only a shortage of staff, there is also a shortage of space. Salford's new building is urgently needed. At present about a dozen buildings are used in addition to the main building. Thus the situation is something like that at Reading in 1950, except that Salford does have a main building. The effect of scattered teaching facilities is rarely anything but harmful. It leads to loss of time because of the traffic of students and staff between the buildings. Organisation is impeded. If a particular department occupies an isolated building it becomes difficult to get in touch with it; and there is a lack of social contact between staffs of departments. Also there is the tendency to indulge in the bad educational practice of three-hour lectures in one building, rather than waste time travelling about between scattered buildings. Queries to staff and attendance registration become difficult.

The need for the new building at Salford has been present for over a decade. In fact, the present building in the course of construction, intended to house the College of Advanced Technology, was designed to be an extension of the previous building. Thus many of the rooms have had to be redesigned, since the building is to be used for a basically different purpose from that for which it was originally intended. As an example of the crowding that led to the original demand for a new building: two years ago tea had to finish early so that the canteen could be used for lectures in the evening; occasionally, classes had to be held in the principal's room. "As far as space is concerned," concluded Dr. Whitworth, "the problem is not how to put a quart into a pint pot but how to make that pint pot hold a gallon."

At present there is no room solely for the use of the principal; his room has to serve for meetings of governing bodies and for any other special meetings. Even with this economy the accommodation for the office staff is very much below standard. In one room about half a dozen typewriters are housed, and registers, accounts, and wages, and the other clerical work associated with the college must be carried out there. Such conditions make any clerical work difficult and must make the already formidable task of recruiting shorthand typists almost impossible.

Shortage of clerical staff is evident at Norwood too. One shorthand typist serves the principal

TABLE 2

Advisory Committee, Department of Telecommunications Engineering, Norwood Technical College

D. A. E. Barnes, A.M.Brit.I.R.E.	Electronics Inspector, P. and O. Steam Navigation Company Limited
R. E. Burnett, M.A., A.M.I.E.E., A.Inst.P.	Radio Industry Council, Member of Governing Body
P. P. Eckersley, M.I.E.E., F.I.R.E.	Consultant Engineer, Telephone Manufacturing Company Limited
H. Faulkner, C.M.G., B.Sc., M.I.E.E., F.I.R.E. (*Chairman*)	Director, Telecommunication Engineering and Manufacturing Association, Member of the Governing Body
G. P. Thorley Lawson, B.Sc., Ph.D.	Training and Education Section, Ministry of Supply
E. M. Lee, B.Sc., M.I.E.E., M.Brit.I.R.E.	Member of the Council of Radio Component Manufacturers' Federation
G. Mole, Ph.D., F.Inst.P. ..	British Electrical and Allied Industries Research Association
A. D. Priestland, M.B.E., F.R.S.E.	Chief Regional Engineer, London Telecommunications Region, G.P.O.
W. S. Procter, M.I.E.E., F.R.S.E.	Chief Regional Engineer, London Telecommunications Region, General Post Office
K. R. Sturley, B.Sc., Ph.D., M.I.E.E.	Head of Engineering Training Department, BBC
A. W. Scott, J.P.	Solicitor, Chairman of the Governing Body
F. J. W. Vogel	Director, Frank Douglas and Company Limited
R. C. G. Williams, B.Sc.(Eng.), Ph.D., M.I.E.E., M.I.Mech.E.	Institution of Electrical Engineers

and four heads of departments in addition to the college secretary and office staff. Space is limited as well, but the college has some amenities that the others lack. There is a reasonable library with room for study and a large intake of technical journals. There are a number of small rooms for full-time staff; although 6 or 7 members of staff are accommodated in each of the six rooms, at any one time many are lecturing, and the remainder are left with some space to themselves. However, lack of teaching space has led to the introduction of two different starting times for classes. Some start at 9 a.m. and others at 10 a.m.; in this way it is possible to use rooms continuously through the lunch hour. Many small rooms, such as work rooms, that are unsatisfactory for teaching are also used. In one instance two classes are held in one large hall.

"The LCC are so cautious," commented Mr. Hillman, "that it is necessary to prove to them that any additional accommodation required can be filled before authority is granted to hire it. Other authorities sometimes prefer to build first a spacious and well equipped college and then to find the students to fill it. The

Continuing Technical College

experience of Croydon and Reading certainly bears out these sentiments."

Yet, in spite of its shortage of space, Norwood is the only one of the four colleges having research assistants: they spend six hours a week teaching, and the remainder of their time on research. One, for example, is investigating the quenching of ortho-positronium in gases. Also the college runs seminars for the staff, with such lecturers as Professor J. D. Bernal and Dr. R. E. Jennings, the latter lecturing on high energy particle accelerators. "In fact," said Mr. Hillman, "the amenities for the staff have improved considerably since we acquired the Jackson building. Before that, the principal's room was the only staff room in the whole building and the principal occupied what is now the secretary's office. There were about 40 full-time staff using that one room." The new building also contains a suitable canteen. As a result the old kitchens have been converted to include, among other things, a replica of a ship's radio room and a battery charging room. A fan that once carried away the smell of cooking now removes fumes from the battery room.

Shortage of space is common to all four colleges. Said Dr. Whitworth: "The difficulty will be enhanced with the 'bulge.' Perhaps there will be a 40 per cent increase in the number of students due to the bulge. The Government are increasing our space by 40 per cent now—so we will be back where we started; overcrowding will still be a problem." At Swindon, where an artificial "bulge" has been created by the influx of many new families, Mr. Gillespie admitted "I don't know what will happen when the bulge comes. I don't think anybody does."

In fact, the present expansion programme, a product of a sudden reassessment of the value of technical education, is anything up to 30 years late. But although there is a national realisation of the urgency of technical education, it is in its own locality that the technical college has to carry out its expansion, acquire land, buildings, and staff. Because of this each has to take great care over its relations with local industry and with the town. Some excellent examples of co-operation exist in the colleges mentioned above, although they are sometimes dependent on one man or are developed in one direction at the expense of others. To ask a technical college to develop a more sensitive outlook to public relations is to add yet another burden to an already under-staffed institution. But the technical college must match the prestige to which it has been raised on a national level with a corresponding increase in its local prestige.

This article has tended to stress the similarities between the various colleges by emphasising the common problems facing them. But there are many differences. The size and make up of the engineering and science departments vary. And they are only a part of the college; they must work in conjunction with other departments covering arts and crafts, commerce, domestic science, catering, general subjects, languages. Courses in such subjects are often taken as a leisure activity and are an important service offered by the college to its local community. In addition, the presence of these departments allows a broadening of technical courses. Thus, at Norwood, students on electronics and radio courses receive speech instruction from the Commerce and Literary Department. Yet in spite of the advantages of co-habitation, it is worth questioning whether many of the non-technical subjects could not be shed to other institutions. Technical colleges being local centres for technical education and being overcrowded, it seems difficult to justify the high proportion of overseas students taking General Certificates of Education at Norwood. And qualified staff being in short supply, why should the principal of Swindon, in common with the principals of Reading, Norwood and Salford, be in charge of ovens?

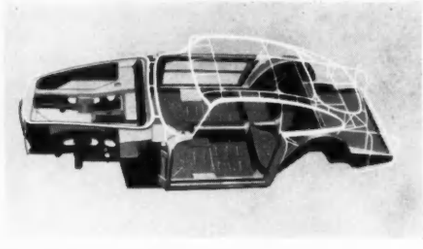
Automobile Engineering

ASTON MARTIN DB4

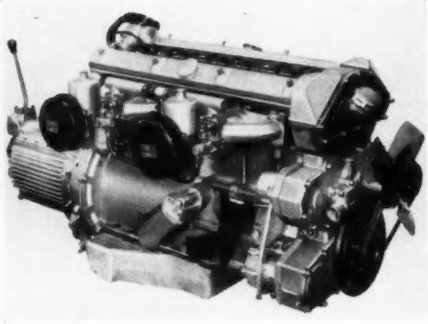
Four-Seater with 3·7 Litre Engine

The David Brown Group have just announced a notable addition to the world's fast cars with the new DB4, a 3·7 litre four-seater coupé with light alloy engine and Dunlop disc brakes to all four wheels. The body design is the first-fruit of the collaboration between Aston Martin and Carrozzeria Touring of Milan. It is being built at the Tickford works, Newport Pagnell, a David Brown subsidiary, where Italian workmen have been instructing the personnel in the Superleggera methods of production.

The DB4 Aston Martin is mainly of light alloy.



The body-work follows Superleggera construction.



A six cylinder engine develops 263 *h.p. gross at* 5,000 *r.p.m.*

Mr. David Brown has long maintained that maximum speed and even acceleration are not a complete indication of a car's usable performance; he therefore claims that this new four-seater closed car will accelerate from 0 to 100 m.p.h. and stop again all in less than 30 seconds.

The six cylinder engine is an interesting new unit with bore and stroke of 92 mm giving 3,670 cc swept volume. It has two chain-driven overhead camshafts and a compression ratio of 8·2 to 1. Gross output is 263 b.h.p. at 5,700 r.p.m. (240 b.h.p. installed at 5,500 r.p.m.) and maximum torque is 240 lb-ft at 4,250 r.p.m. Cylinder block and crankcase are a single deep light alloy casting with a skirt extending well below the crankshaft, and there is a wide cast aluminium sump. Cylinder liners are of centrifugally cast chromium vanadium iron. The head also is in light alloy, carrying the camshafts which operate valves inclined at an included angle of 80°. The valves are operated direct through hardened nickel molybdenum steel tappets requiring no adjustment, and exhaust valve guides are in direct contact with the coolant. Combustion chambers are fully machined.

The two horizontal SU HD8 diaphragm-type carburettors with simple disc-type air cleaners are mounted on a pair of three-branch inlet pipes connected by a large-bore balance pipe. On the opposite side are two separate exhaust pipes. The ignition distributor, with centrifugal and vacuum control, is driven from the rear end of the inlet camshaft. The crankshaft runs in seven steel-backed copper-lead bearings and carries a damper on its front end.

Lubrication is effected by a front mounted chain-driven Hobourn-Eaton oil pump and there is a full flow Purolater filter in the system. Cooling is by pump and fan with by-pass thermostat control. The cross flow radiator has a seperate header tank.

The drive goes through a 10 in Borg and Beck clutch to a new David Brown four-speed gearbox, with baulk-ring Synchromesh for all forward speeds, in a finned aluminium casting, a Hardy Spicer needle roller bearing propeller shaft takes the drive to the Salisbury hypoid rear axle.

Effects of the collaboration with Carrozzeria Touring are evident in the total departure from previous Aston Martin chassis design. The new chassis is a platform structure in steel sheet with reinforced sides, making a unit with scuttle front wheel valances and luggage trunk floor. Integral with it is a light tubular structure for screen frame, roof and rear wings, the whole structure being covered with light alloy panels.

Front suspension is by double wishbones and coil springs with anti-roll bar and telescopic Armstrong dampers. Steering is by David Brown rack and pinion with an offset universally-jointed column adjustable for angle. The rear axle is located by radius arms and a transverse Watt linkage. The coil springs are behind the axle giving a spring base longer than the wheelbase, and double acting piston type dampers are used. Centre lock wire wheels carry 6·00-16 tyres. Dunlop disc brakes with vacuum servo assistance are used on all four wheels. The fly-off handbrake, which has a pull-up lever alongside the driving seat, takes effect on separate calipers on the rear discs.

The body style is a neat modern creation with wrap-round windscreen and big rear window. Bumpers and other fittings are neatly blended into the basic line. Interior finish is in leather with a padded facia carrying an inset support handle for the front passenger. Front seats have Reutter reclining backrests and the two rear seats are fairly small but well shaped. The luggage locker is big and unobstructed, with the battery located in a separate locker at the side. The spare wheel is carried in a separate water proof and dirtproof compartment under the boot floor.

A comprehensive heater and demister system is provided with separate controls on each front door pillar.

The new DB4 is built entirely within the David Brown car production factory which is now centred on the Newport Pagnell works.

Dimensions: wheelbase 98 in; track, front 54 in; rear 53½ in; length 176⅜ in; width 66 in; height 51½ in; ground clearance 7 in; turning circle 34 ft; kerb weight 2,884 lb; tyres 6·00-16 on centre lock wire wheels; electrical system 12 volt 51 Ah.

Companies in the News

Polymerous ICI

In the same week Imperial Chemical Industries has been involved in two important announcements resulting in an expansion of its interests. First, an arrangement has been made with Ilford Limited in the field of colour photography. ICI has carried out extensive research on dyestuffs in their relation to colour photography and an agreement has been made between the two firms to save Ilford from investing considerable resources in basic research work in a competitive field.

ICI was on the point of marketing a product of its own and the new arrangement has the advantage from Ilford's point of view that it husbands capital resources and prevents competition being intensified by a newcomer. Ilford therefore propose acquiring from ICI technical data on colour photography and such production assets as it may choose on terms to be agreed, while ICI carry out at cost for Ilford such research work as Ilford may require in return for royalties on future sales of colour film. If the agreement goes through ICI will hold 32 per cent of Ilford's share capital in five year's time.

ICI have also entered into a new venture in the United States in collaboration with the Celanese Corporation of America. The two concerns propose making Terylene in the United States and it will be marketed under the trade name Teron. It will be marketed by Celanese Corporation. It is expected that the eventual capacity of the new plant to be located in Delaware will be 40 million lb of fibre a year. Both continuous-filament yarn and staple fibre will be made. It seems probable that the cost will be in the region of £45 million.

It will be recalled that for many years ICI and du Pont exchanged information and patents and that this arrangement was killed by the anti-trust laws in the United States. Since then the two big chemical groups have become increasingly interested in competing in each other's domestic market. The United States patent rights in Terylene, which expire in 1961, were sold by the Calico Printers Association Limited to du Pont, which makes the fibre under the name of Dacron.

Imperial Chemical Industries has now found a partner to enter upon the production of Terylene in the United States market. The decision must have been based on fairly optimistic calculations of the future of Terylene alias Dacron, for du Pont are well established. There is, of course, always an argument for an alternative supplier and ICI may have decided that it would be as well to become that alternative in the United States market before the manufacture of Dacron becomes a free-for-all in 1961.

Electricity Account

The increasing efficiency of electricity generation is reflected by the figures given in the *Report and Accounts* of the Central Electricity Authority, recently published. Whereas during the year 1957-58 the electricity generated rose by 8·9 per cent, the fuel consumed rose only by 6·6 per cent. There has, in fact, been a steady improvement from the thermal efficiency figure of 20·91 per cent for the steam power stations as a whole in 1947-48 to 25·51 per cent for the year ended 31 March, 1958. The figure for the previous year was 24·93 and if the average had remained on that level another 1,062,000 tons of coal would have been consumed at an approximate additional cost of £4·3 million. Of the total units generated, 99·7 per cent were produced by steam plant using coal, coke breeze, or oil.

The average price received for electricity sold for all purposes was 1·534*d* per unit. This was 4·4 per cent above the 1956-58 figure and 34 per cent above the average for 1947-48. These increases as a whole, point out the Authority, are very much less than the price increases for practically all other commodities and services, and far below the increases borne by the supply industry for plant and equipment, civil engineering works, buildings, coal, materials, goods, and services.

The net surplus of the industry for the year was £16,062,039. This sum is less than 4 per cent on the year's combined revenues of £474,000,000; and under 0·7 per cent on the £2,313,000,000 invested in fixed assets. Although there were further increases in costs these were covered by the retail tariff adjustments subsequent to the voluntary tariff standstill from June 1956 to March 1957. These, added to a recovery in the rate of growth of consumption, largely accounted for the increase of £4·34 million in the consolidated surplus.

Plans have been made by the Board to increase their generating capacity by 44 per cent during the six calendar years 1958-63. This represents a net addition of some 9,800 MW of output capacity, including some 1,575 MW of nuclear plant. Altogether some 11,900 MW of new plant are expected to be provided, while about 2,100 MW of old plant are to be shut down. New plant brought into service during 1957-58 provided an additional output capacity of 1,700 MW. The total maximum output capacity with all plant in service at 31 March, 1958, was 22,343 MW.

Electricité de France

The consumption of electricity in France is doubling every ten years. Despite credit restrictions and other anti-inflationary measures, the directors of Electricité de France have not, so far, observed any influence on their sales. Electricity sold is increasing at an average rate greater than that of industrial production generally, 8·1 per cent, compared with 7 per cent.

The only unfavourable factor would appear to have been rising costs, particularly costs of new power stations and distribution equipment. This has forced the undertaking to delay for six months several items included in their 1957 programme, as they are committed to participation in the Government's efforts to check inflation and improve the country's balance of payments. They consider that the delays, however, cannot but have "an unfavourable impact upon our objectives."

The Electricité de France report contains a most interesting detailed account of the year's operations, excellently illustrated by coloured graphs, maps and tables. The production of hydraulic electricity was reduced by serious floods which caused extensive damage to some power stations and other unfavourable factors related to the weather. Over the year, 43 per cent of total consumption was supplied from hydraulic sources and 57 per cent from thermal sources. No atomic electricity has yet been produced: the first power station is scheduled to go into service at the end of 1959, the second, which has just begun construction, in 1961 and the third will be started during next year. There is a possibility of Electricité de France using enriched fuels as a result of the recent agreement between Euratom and the United States.

Electricité de France made a profit of Fr 4,500 million, with the comment that "the increase in our costs was more than compensated by increases in productivity and certain tariff adjustments." Nonetheless, difficulties remain in the field of capital investment. The Government's refusal to authorise more than Fr 221,000 million for the current year (based on prices ruling at June 1957) has led to cuts in the thermal station programme and a complete standstill in hydraulic operations. Electricité de France's report suggests that these restrictions may disrupt the whole pattern of their development.

British Motor Corporation Service

Two new factories and improvements in service organisation are the latest moves by the British Motor Corporation in the competitive race for the car market. The multiplicity of BMC models creates many service problems and efforts are currently being made to solve them rationally.

The policy adopted in the case of models no longer manufactured is for the service company—BMC Service Limited—to make a "terminal buy" of eight times the previous year's usage of spare parts for a model as soon as production ceases. BMC have also adopted a policy of "commonisation of parts and components" to make them interchangeable to an increasing extent between the various models. This is expected greatly to reduce the number of "parts item headings," at present some 20,000 fast-moving and 80,000 comparatively slow-moving parts and components.

BMC Service Limited, founded in 1956 to combine and co-ordinate the activities of the various Austin and Nuffield service departments, are organised in two operational divisions, known as "Service Parts" and "Service Technical."

Each of the divisions will keep in close touch with distributors and dealers to ensure that they are doing their job properly and are adequately equipped. A fieldman from Service Parts will visit each distributor at his premises at least twice a year and will see as many dealers as possible to examine and advise on the parts operation system. Adequacy and control of stock, method and arrangement of storage, price maintenance and standard of service are the main headings under which these examinations will be carried out. Service Technical will attempt to set and maintain among distributors and dealers standards of equipment and of staff training. Courses are held at the group's Cowley school for distributors' personnel. Apart from keeping distributors and dealers well informed on technical matters, Service Technical will record "defects and all relevant details so that an analysis might reveal facts which can be used for future design or production improvement."

A large expansion of the BMC factory in Durbar Avenue, Coventry, will enable it to increase output of replacement engines and gearboxes to 4,000 a week by mid-May, doubling the present figure and making more space at other engine factories for the production of current model engines and gearboxes. At Cowley a new paint plant has been built, covering seven acres and costing £3 million. Output of rust-proofed and completely painted car bodies will be at the rate of one a minute. Central paint supply has been organised so that any of 26 different colours can be supplied to almost totally automatic spray booths in which 3,000 gallons of paint will be used each week.

Double Brew

Ind Coope and Allsopp and John Labatt of London, Ontario, are to form a "close association" to pool technical, commercial and scientific resources. In their announcement, Ind Coope point out that the agreement "brings into joint harness perhaps the greatest single accumulation of brewing research, brewing skills and brewing marketing and distribution experience anywhere in the world."

A feature of the new association will be the pooling of technical resources, which should strengthen the engineering resources of both companies. There have been many changes since the war in the organisation of the food and drink industries, and a substantial increase in the average size of undertakings. This will doubtless have a powerful influence on the design and utilisation of plant and machinery. The tendency to can and bottle beer has already led to substantial advances in continuous bottling, processing and packaging machinery.

Atomic Review

Directions

PERSPECTIVE of nuclear power planning—advances in nuclear engineering—new reactors and reactor concepts. Where items have been taken from Geneva Conference papers, references are given.

Changed Estimates for Nuclear Power Costs

Since 1955 estimates for the cost of power from nuclear power stations in the United Kingdom have undergone certain changes.

Interest Rate.—In 1955 it was considered that the appropriate rate was 4 per cent for the United Kingdom. Present estimates are based on 5 per cent and a case could be made for taking an even higher rate up to, say, 6 per cent. Owing to the high capital cost of nuclear stations, this change in a non-technical and non-nuclear factor leads to an increase in total cost of at least 10 per cent or up to 0·1*d* at kWh.

Capital Cost.—The capital cost of the first four nuclear power stations (excluding site development charges, etc.), is now seen to be between £110 and £130 a kW compared with the figure of £125 assumed in 1955. It should be noted, however, that the stations are much larger than assumed previously (300-500 MW instead of 150 MW) and that the cost would have been higher per kW if stations of the expected size had been built.

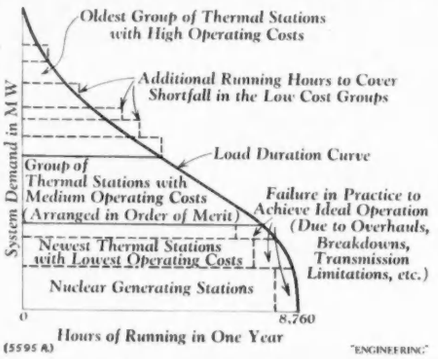

Oldest Group of Thermal Stations with High Operating Costs
Additional Running Hours to Cover Shortfall in the Low Cost Groups
Load Duration Curve
Group of Thermal Stations with Medium Operating Costs (Arranged in Order of Merit)
Failure in Practice to Achieve Ideal Operation (Due to Overhauls, Breakdowns, Transmission Limitations, etc.)
Newest Thermal Stations with Lowest Operating Costs
Nuclear Generating Stations
System Demand in M W
0
8,760
Hours of Running in One Year
(5595 A)
"ENGINEERING"

Fig. 1 Load duration curve on a yearly basis for a purely thermal power supply system.

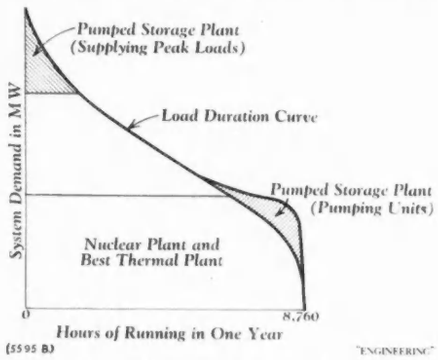


Fig. 2 Effect of introducing pumped storage into a power supply system.

Site Development and Central Engineering Charges.—The 1955 estimates included no allowance for these. This was an error. It was not at the time realised that the quoted capital costs of coal-fired stations normally included an allowance for them, nor that their magnitude would be as great. They amount to about 5 to 10 per cent of the capital cost and add about 0·04*d* a kWh to the cost of electricity.

Life of Station.—No effective change, but the life of the whole is now taken as 20 years.

Thermal Efficiency.—The 1955 estimates were based on the thermal efficiency of Calder Hall which, being optimised for plutonium production, is in the region of 20 per cent. To take the same figure for the civil stations represented a quite unnecessary degree of caution. In practice the thermal efficiencies are in the region of 27 per cent or 35 per cent higher than estimated earlier. This affects the capital cost per kWh, the fuel replacement cost per kWh and also the initial fuel cost per kW and the effect on the cost of electricity of the credit for plutonium.

Initial Fuel Charge.—Because the thermal efficiency is higher (see previous point), the cost per kWh is lower, but this is offset by the higher interest rates now assumed. A more sophisticated method is now adopted for depreciating some of the initial charge. Although the effect on the average cost of electricity will be slight, there is still considerable uncertainty over the exact method that will be adopted in discharging the first reactor fuel charge and this will affect the costing of the initial fuel charge.

Load Factor.—In 1955 a load factor of 80 per cent was assumed. The Electricity Boards have thought it prudent to assume 75 per cent. This is not a technical change—there is no additional information suggesting that one figure is better than the other—but a change in convention which is accordingly adopted here.

Cost of Fuel.—The basic price of the Calder Hall type fuel elements is at present not greatly different from the £20,000 per tonne previously estimated. The cost of replacement fuel per kWh will therefore be less owing to the higher thermal efficiency.

Level of Irradiation.—The additional information obtained since 1955 has not led to any need to revise the estimate of the level of irradiation that will probably be obtainable.

Value of Irradiated Fuel.—Views on the probable value of irradiated fuel have altered, both because the value now attached to plutonium is lower and also because it is thought prudent to assume rather higher processing costs than were implicit in the paper given in 1955. It should also be noted that the higher thermal efficiency now probable considerably reduces the importance of the value of irradiated fuel in determining total generating costs. As a result of these changes the effect of the credit for plutonium on the cost of electricity is reduced to only 10 per cent.

Although the principles behind the valuation of plutonium have not changed, there are two reasons for a lower value to be attached to it now. Firstly its use in thermal reactors (fast reactors are not likely to take up all the plutonium for at least ten years) will compete with natural uranium, and its value will therefore be related to the market price of natural uranium which is showing a tendency to fall, chiefly owing to the greater abundance of supplies than was previously thought. Secondly, the United States have published prices for uranium 235, which are considerably lower—particularly for slightly enriched material—than implicit in the figures given in 1955. As plutonium will be used as a substitute for slightly or highly enriched uranium, it is reasonable to reduce its estimated value in line with the fall in the uranium 235 price.

The total cost of electricity is now estimated at being slightly higher than that estimated three years ago. Thus the total cost per kWh sent out is given for 1955 as 0·43 to 0·59*d* (150 MW station); for a 275-300 MW station completed 1960-61 as 0·70 to 0·77 or 0·74 to 0·81*d*; and for a 500 MW station completed by 1962 as 0·59 to 0·66*d* or 0·63 to 0·70*d*. The alternative estimates depend on the interest rate, which is taken as 5 or 6 per cent. (J. A. Jukes, *Economics of Nuclear Power*, P72 UK.)

Nuclear Power in Britain and Peak Load

Speaking at the recent meeting of the British Association in Glasgow, on "Nuclear Power and the Engineer," Sir Christopher Hinton made the following observations.

The cost of electricity generated in the nuclear power plants which are under construction is estimated to be between 0·66*d* and 0·7*d* per unit. Based on current prices, power will be produced from the best conventional plants which are being built to-day at a cost of only 0·54*d* per unit and it is therefore obvious that the present nuclear power plants can only be justified as the foundation for improving nuclear technology. But in calculating the nuclear power cost of 0·66*d* to 0·7*d* per unit it has been assumed that these nuclear power plants will be used for base load only and will not be asked to take any share of the peak load. In a conventional power plant only about one-third of the cost of each unit of electricity generated arises from capital charges, the other two-thirds arising from fuel and operational charges. In the nuclear power plants which are at present being built this proportion is approximately reversed and two-thirds of the cost of each unit of electricity generated arises from capital charges, while only about one-third arises from fuel costs and operating charges. It is therefore obvious that if the present nuclear power plants are asked to take a share of peak load and therefore to work at a lower load factor, they will be placed at a great disadvantage as compared with conventional plants. This was not a matter of great concern at the time when the first plan for nuclear power was issued as a White Paper in 1955. That plan envisaged that by 1965 about 1,800 MW of nuclear power plant capacity would be installed. At such a rate of expansion it would be possible to use nuclear power plants on base load for a considerable time. But for various reasons the plan was expanded in 1957 and now envisages an installed nuclear capacity of about 5,000 to 6,000 MW by 1966. At this rate of expansion nuclear power plants will have to carry a share of peak load by 1971 or 1972. This means that the nuclear power plants which are inquired for in 1966 and ordered in 1967 must have capital costs which are so much reduced as to enable them to compete with conventional power plants when taking a share of the peak load.

Speakers in discussions at Glasgow remarked that xenon poisoning made the present design of station essentially a base-load plant, and that it was important to look for reactor systems capable of operating economically as peak-load units.

Load Factor

Improvement in overall load factor is primarily a matter of encouraging demand at off-peak periods. However, the same effect can be achieved in the generation system by the application of energy storage methods. A load duration curve, on a yearly basis, for a purely thermal system is shown in Fig. 1. Plants having low running costs occupy the lower part of the curve and carry the bulk of the load. The middle portion of the curve is occupied by older machines running on less advanced cycles and at lower load factors. Peak loads, at the top of the curve, are carried by old time-expired plants with complete economic justification, even when their running costs are as high as 1·5*d* or 2·0*d* per unit, owing to the short duration of the peaks.

The effect of introducing pumped storage into the scheme is shown diagrammatically in Fig. 2. Basically a means is provided for pumping large masses of water from a low-level reservoir to a higher one. This is done at the light load periods and helps to fill the valleys in the load curve.

At periods of peak load the process is reversed and the head of water in the high level reservoir is used to generate electricity. In practice, there are refinements to this simple system, in order to utilise the additional pumping periods available at week-ends. (J. C. Duckworth, E. Hywell Jones. *Economic Aspects of the United Kingdom Nuclear Power Programme.* P1446 UK).

Polyzonal Spiral Fuel Element

The outstanding feature of the industrial nuclear power stations now under construction in England is the immense increase in output compared with their forerunner, Calder Hall. The heat release per unit core volume in these designs of gas-cooled graphite-moderated reactors fuelled with natural uranium has, in the case of

the power stations for Bradwell in England and Agip in Italy (Nuclear Power Plant Company), been achieved essentially by the development of the polyzonal spiral fuel element. . . . The problem of heat removal from a gas-cooled reactor fuelled with natural uranium arises mainly from the nuclear demand for the greatest possible compactness of the fuel while thermodynamically the highest possible surface to volume ratio would be preferred. The problem is aggravated by the need to remove and transport the heat by a gas of low conductivity and thermal capacity. Nuclear considerations seem invariably to lead to a gas channel of about 4 in diameter containing a solid or tubular uranium rod of slightly more than 1 in diameter from each foot length of which 10 to 20 kW heat have to be extracted with the smallest possible temperature difference between gas and uranium surface and with the least expense in pumping power.

Three means of achieving a high heat transfer are available, aerodynamically the most economical being to raise the temperature of the heat delivering surface high above the temperature of the coolant. The use of metallic uranium, however, precludes the application of high temperatures. . . . If it has to be accepted that the temperature difference between can and gas is limited, then the next obvious way of obtaining high heat transfer is to increase the heat transferring surface by attaching fins to the canning material. . . . The third way of achieving high heat transfer by increasing the heat transfer coefficient by means of enforced turbulence is in general expensive as it entails relatively high frictional losses.

A comprehensive research programme was consequently initiated aimed at the development of effective means of creating an intense, well defined flow in the flutes between the fins and replenishing it at regular intervals from the main gas stream. After several unsatisfactory attempts the solution was found in the application of a phenomenon well known in aerodynamics. A feature of the swept-back wing is that it creates, at high angles of incidence, a continuous intense vortex, along its span. The question then arose as to why spirally finned surfaces with long leads do not develop this flow and thus differ essentially from longitudinally finned surfaces. The answer was found to be that the wall in the direction of flow, normally provided by the aircraft body or by the plane of symmetry between two swept-back wings, was missing. The insertion of longitudinal radial walls into the spiral fins consequently produced the desired flow pattern. The resulting fuel container, shown in Fig. 3, consists of a cylindrical barrel with a smooth bore and a finned outer surface. The fins are disposed in a helical fashion about the central axis of the container forming a multistart spiral of a fairly long lead. Longitudinal slots are cut into the fins at regular intervals round the perimeter into which splitters are inserted extending from the barrel to a position radially close to the wall of the flow channel.

The effect of this arrangement is that the gas approaching the line of fuel elements stacked for example on top of each other in one flow channel is subdivided by the splitters into several identical zones. The flow patterns developing in each zone are quite independent of each other but are identical and determined by the fact that the approaching gas is gradually consumed by the flutes between the fins, forming intense vortices when entering these at their upstream ends. It then follows, in a helical path, the flutes to their downstream ends where it is, on impact with the longitudinal splitter, deflected radially outward into the main gas stream where the hot filaments emerging from the flutes share their heat with the bulk of the flow. Deflected again, first by the circular wall of the flow channel and then by the next splitter, it reaches the upstream ends of a further set of flutes where the same process is repeated. The overall effect is that the cooling gas, while following a generally axial direction with respect to the fuel container, flows in a helical path around an axis which is itself a helix resulting in the development of a high heat transfer coefficient on the surface of the fins and in the continual replacement of the gas in contact with the finned surface by gas from the main stream, that is, by gas of about bulk temperature. . . .

Developing one quadrant of a polyzonal element into an oblong and supplementing it by its mirror image produces a flow channel with one row of inclined fuel plates in its centre as shown in Fig. 4. This arrangement creates two helices, one on either side of a central ladder, turning in opposite directions. (H. L. Ritz—Chief Research Physicist, C. A. Parsons and Company Limited—*The Polyzonal Spiral Fuel Element*, P48, U.K.)

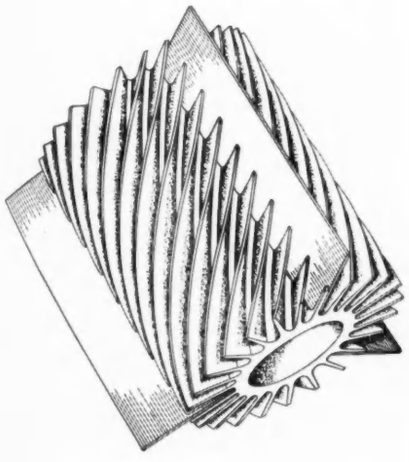


Fig. 3 (top left) Polyzonal spiral fuel can designed to give increased efficiency of heat transfer.

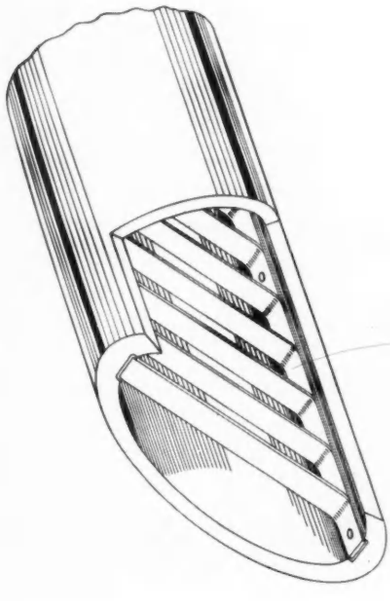


Fig. 4 (left) Ladder fuel element, a development of the polyzonal spiral principle

Fig. 5 (right) Shock absorber devised by the English Electric Company for protecting the structure of a nuclear reactor from damage should a control rod be accidentally dropped.

Buffer Cans for Control Rods

A simple shock absorber to prevent possible damage to the reactor structure should a control rod be accidentally dropped has been devised by the Whetstone Laboratories of the English Electric Company. The buffer comprises a 2½ in o.d. by 22 gauge FDP stainless-steel tube softened and crimped as shown on the left of Fig. 5. After impact the initial deformation is augmented by further corrugations thereby absorbing the energy of collision. The centre tube in the illustration has absorbed 1,000 ft-lb, and the one on the right 2,000 ft lb.

Putting Wigner Energy to Use

The rate of build up of Wigner energy in graphite as a result of fast neutron irradiation is dependent on the temperature. The temperature distribution in the core is such that the storage of Wigner energy does not constitute a problem in the upper part of the core where the coolant gas—and therefore the graphite—is building up to its outlet temperature. At the same time approximately 6 per cent of the heat produced by the reactor is as a result of the collison processes as the fast neutrons are slowed down to thermal energies in the moderator. Thus this 6 per cent of the heat output is actually produced in the graphite itself. The fuel element design in the Hunterston nuclear power station (GEC—Simon-Carves), employing as it does a graphite sleeve to support the cartridge, is such that use may be made of this 6 per cent of heat to raise the temperature of the lower part of the moderator above the level of the incoming gas. Thus by preventing a flow of gas in the annuli between the outside of the graphite sleeves and the wall of the channels an insulating effect is secured, and the temperature of the lower part of the moderator rises. In this way the build up of excessive amounts of Wigner energy in the lower part of the core is avoided in a simple and effective manner.

Steam Cycles for Advanced Reactors

The table on page 438 shows the steam cycles and operating conditions that are most appro-

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TABLE.—*Steam Cycles and Operating Conditions Appropriate to Various Stages in the Development of the Gas-Cooled Reactor*

Reactor coolant outlet temperature	°C (°F)	350 (660)	400 (750)	450 (840)	500 (930)	550 (1020)	600 (1110)
„ „ inlet temperature*	°C (°F)	177 (350)	222 (430)	260 (500)	294 (560)	320 (610)	343 (650)
Type of steam cycle	—	Dual pressure		Dual pressure		Super-critical pressure with reheat	
H.p. steam pressure	lb per sq. in (kg per sq. cm)	600 (42)	920 (65)	2,000 (140)	2,800 (196)	3,500 (245)	5,500 (386)
„ „ temperature	°F (°C)	640 (337)	730 (387)	820 (438)	910 (487)	1,000 (537)	1,090 (590)
L.P. steam pressure	lb per sq. in (kg per sq. cm)	150 (10·5)	230 (16)	500 (35)	860 (60)	—	—
„ „ temperature	°F (°C)	620 (327)	710 (376)	820 (438)	910 (487)	—	—
Reheat pressure	lb per sq. in (kg per sq. cm)	—	—	—	—	1,200 (84)	1,800 (126)
„ temperature	°F (°C)	—	—	—	—	1,000 (537)	1,090 (590)
Proportion of H.P. steam	per cent	60	64	67	79	100	100
Feed water temperature	°F (°C)	200 (93)	375 (191)	455 (235)	515 (268)	520 (272)	580 (305)
Turbine cycle efficiency	per cent	28·2	33·5	38·0	41·0	43·5	45·0
Turbine exhaust moisture	per cent	13·5	14·0	10·5	11·5	11·5	12·0
Station overall efficiency	per cent	15	30	34	37	39	40·5
(Station overall efficiency attainable with single-pressure steam cycle and corresponding turbine exhaust moisture)	per cent	(23·0) (11·0)	(28·0) (12·5)	(31·5) (14·5)	(34·5) (†)	(36·5) (†)	(37·5) (†)

* Coolant temperature at inlet to circulators. † Excessive moisture content.

priate to various stages of development of the gas-cooled reactor. A rapid increase in attainable steam pressure follows upon modest advances in reactor coolant outlet temperature. In turn, the anticipated overall thermal efficiencies show attractive improvements. At the present time, with coolant temperatures limited to about 400° C, it is not possible to make effective use of feed-heating as this can be introduced only at the expense of steam pressure. As the coolant temperatures rise, however, it becomes possible to use feed-heating to greater advantage and, with a foreseeable coolant temperature of 600° C, cycles working with very high steam pressures and using the maximum amount of feed-heating become feasible.

Much of this potential improvement stems from the fact that, as the reactor coolant outlet temperature is raised, it is permissible to elevate the inlet temperature as well. How far it is possible to go with the latter depends on the characteristics of the future gas-cooled reactors, a relatively unknown field. What can be done, nevertheless, is to make certain conservative assumptions in this connection. One of these is to concede that the higher-temperature reactor will demand a higher coolant pressure loss and this has been taken into account in the analyses supporting the trends given in this paper. Another is to concede that the coolant circulator power consumption will remain 10 per cent of the electrical output of the plant. This is tantamount to conceding that the " nuclear boiler efficiency " will remain at 94 per cent, where it is to-day. (W. R. Wootton *et al*, *Steam Cycles for Gas-Cooled Reactors*, P273, UK.)

Turret Gas-Cooled Reactor Concept

A gas-cooled reactor employing a system of turret loading for fuel elements, whereby the core itself rotates (Fig. 6), has been proposed by the Los Alamos Scientific Laboratory. Details of the system have recently been summarised in *Nuclear Technology Briefs—Power Reactors*, prepared for the USAEC by Dr. Walter H. Zinn and associates of the General Nuclear Engineering Corporation of Dunedin, Florida. The arrangement of the reactor permits the use of an uncanned non-metallic fuel element, the advantages of which are the high coolant temperatures attainable, high neutron economy, and simplified fuel processing; the main disadvantage is the release of fission products into the coolant circuit.

The design proposed is graphite moderated and the fuel consists of graphite elements impregnated with highly enriched uranium oxide. Lower enrichments would be possible with larger reactors. The plant would have an electrical output of 20 MW and employ nitrogen at 500 lb per sq. in as coolant and as working fluid for a directly coupled gas turbine. The outlet temperature of the nitrogen would be 1,300° F (700° C) and an overall efficiency of 30·2 per cent is expected.

The turret reactor is so called because it employs a system of fuel charging and discharging whereby the reactor core itself rotates, enabling the horizontal fuel channels to correspond in turn with stationary loading ports in the side of the pressure vessel. The core is cylindrical and is pierced along its axis by a large-diameter gas inlet plenum. The coolant flows radially outwards from the central plenum to an outer annular plenum at the periphery of the core. The core cylinder, 9 ft in diameter and about 6 ft high, comprises a stack of 40 graphite discs, which are so constructed as to provide 36 square radial fuel channels in each disc. The channels, ¾ in square, are loaded with tubular fuel elements, about ¾ in o.d. and ½ in i.d. The elements are loaded by a ram which pushes them into place through ports in the wall of the pressure vessel.

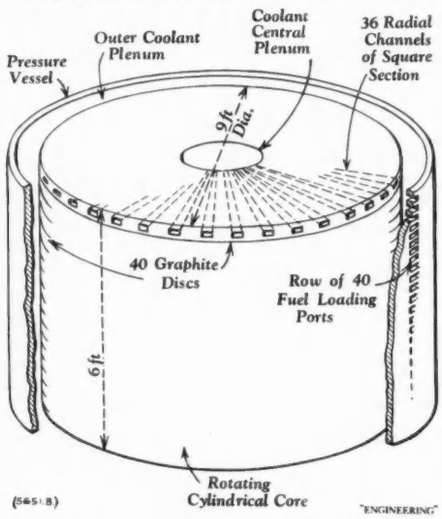


Fig. 6 Arrangement of turret gas-cooled reactor.

The core is mounted on a rotating table which allows each fuel channel in a given layer to be brought opposite a loading port. A vertical row of ports serves each of the 40 layers of radial fuel channels.

ALPR Critical

The Argonne Low Power Reactor (ALPR), the prototype of a nuclear reactor designed to produce electric power and space heat at remote military stations, achieved criticality on 11 August at the United States Atomic Energy Commission's National Reactor Testing Station, Idaho Falls, Idaho. The prototype is undergoing tests prior to operating at full power of 3 MW (thermal). ALPR is a package plant designed to be erected on any type of terrain and with a minimum of on-site construction. It contains a direct-cycle, natural-circulation boiling-water reactor, fuelled with enriched uranium, and moderated with light water. The heat from the reactor can be used to generate 260 kW of electricity and 400 kW of space heat. The reactor is designed to operate for three years with each fuel loading. Most of the reactor core and all of the fuel elements are fabricated of alloy X-8001, an alloy of aluminium and nickel developed by Argonne. The alloy is economical to fabricate and process.

Notes and News

Seventh Nuclear Power Station Site

The Central Electricity Generating Board are to make application to the Minister of Power and to the local planning authority for consent to develop a site at Sizewell for their sixth nuclear power station. The South of Scotland Electricity Board also has a nuclear station (300 MW) under construction at Hunterston, making seven in all.

Sizewell has been selected after an extensive survey in Suffolk as the site most suitable for development for nuclear generation at the present time. The site area is mainly heath and woodland on the coast two miles to the east of the town of Leiston. The subsoil is capable of supporting heavy reactors, and vast quantities of water required for cooling purposes can be taken from the deep water which is reasonably close inshore. The area is generally above flood level and locally the coast line is stable.

The proposed power station will have an output capacity of about 650 MW and the site is capable of further development. The station would be connected to the 275 kV national grid system by transmission lines proceeding westward from the site. Three nuclear power stations are now being built by the Board at Berkeley, Gloucestershire (275 MW); Bradwell, Essex (300 MW); and Hinkley Point, Somerset (500 MW). Preliminary works have been started for the construction of a fourth station at Trawsfynydd, Merionethshire (500 MW) and application has been made for consent to develop a site at Dungeness for the Board's fifth nuclear power station.

Manager for Winfrith

Mr. D. W. Fry, deputy director of the Atomic Energy Research Establishment, Harwell, is to be responsible to Dr. B. F. J. Schonland, director of the UKAEA Research Group, centred at Harwell, for the management of the Winfrith Heath establishment in Dorset. Mr. Fry has been in charge of thermonuclear work at AERE. The news of his appointment follows the announcement that, in addition to work on the high-temperature gas-cooled reactor, the main thermonuclear effort will be at Winfrith.

Second Italian Contract

A boiling-water reactor power plant employing enriched uranium is to be built on the Garigliano River south of Rome. The contract for the 150 MW station has been awarded by SENN (Societa Elettro Nucleare Nazionale) to International General Electric, a division of the American General Electric Company. A gas-cooled reactor power station is to be built in Italy by the Nuclear Power Plant Company.

The Human Element

Mountain to Mohammed

Some measure of the difficulty in getting scientific personnel into the technical sections of the Civil Service can be gathered from the annual report of the Civil Service Commissioners for 1957/58 which was published last week (HMSO, price 2*s*). Over the recruitment field as a whole there was an improvement compared with the year before. Successful candidates in open competition went up from 11,606 to 13,057.

Concern continued to be felt about the lack of qualified young entrants to engineering posts. There was a fall in the intake to higher scientific classes. An effort was made during the year to recruit for research fellowships young British scientists who had gone to the USA or Canada to do research work. Interviews took place in Ottawa and in Washington. This was done in co-operation with the United Kingdom Atomic Energy Authority and, according to the Commission, has shown useful results.

It is noticeable that the trend towards entry by examination of the academic type is growing. The interview and group test techniques are now less in favour for Foreign Office recruitment. This seems to be a general trend these days. The commonsense idea that a man who writes clearly and intelligently probably also thinks clearly is regaining lost ground. In the Civil Service there must always be a premium on clear thinking and good drafting. These in turn depend on a good educational and technical background in the case of the scientific grades, and there are still signs that the Civil Service is trying to get them at below the market price.

Sound and Equitable

Peace came back to the United States motor industry only six hours after Ford's 98,000 hourly-paid workers had walked off their job in response to a strike call from the United Automobile Workers' union. The settlement was described by the heads of the two bargaining teams—Ford vice-president John Bugas and UAW president Walter Reuther—as " sound and equitable . . . in the best interest of the company, the workers and the American public." Why it should require strike action to discover this paragon of solutions was left unexplained. The effect of the agreement was one of general relief for the conflict threatened to be on a national industry-wide scale. Last month, the AFL-CIO executive board (equivalent to the British TUC) had unanimously voted to set up a special committee of top trade-union leaders " to marshall the resources of the whole labour movement behind the UAW." When the Ford workers answered their union's strike call, the United Steel Workers of America—then at their biannual delegate convention—voted their " entire treasury " to the support of the UAW, " should it find a major strike on its hands."

The Ford offer was almost immediately followed by similar offers by General Motors and Chrysler. In each case the UAW had threatened a strike for 30 September. Agreement is expected to be reached and no serious strike is now likely. Although the precise terms of the Ford agreement have not yet been published, they are expected to include an increase of 10 cents (9*d*) an hour retroactive to 1 July, another 7 cents an hour on 1 July, 1959, and the same in 1960.

Teachers Galore

A vast expansion is to take place in the capacity of teacher training colleges, providing 12,000 new places in three years. Announcing the Government's scheme, Mr. Geoffrey Lloyd, Minister of Education, said that the three-year programme is designed to cause the minimum interference with the annual output of teachers from the colleges. About 50 colleges will be expanded and some of them more than doubled in size. Several new colleges will be built and sites for these are currently being considered.

Mr. Lloyd said that one of the main objectives of the Government was to bring down the sizes of the classes as soon as possible. This would mean a much bigger increase in the number of teachers than was thought necessary a year or so ago, and reflects a most important change in the Government's attitude. He emphasised that there was to be " no going back " on the decision announced last year to lengthen the general training college course from two to three years (starting in 1960). Within the programme, special measures would be taken to train extra teachers of science and mathematics.

The new proposals, which will cost some £15 million, are thought inadequate by the National Union of Teachers. Their general secretary, Sir Ronald Gould, said that the proposed expansion was " some 4,000 places below the minimum considered essential by the National Advisory Council on the Training and Supply of Teachers."

Early to Learn

The education we received in early years is considered to be the key to later learning. A most ambitious survey of attitudes to education and sources of people's ideas—carried out by Dr. Joseph Trenaman, further education liaison officer of the BBC (with the help of the Nuffield Foundation)—found that early education has, in fact, " a more profound and more lasting influence than many have been inclined to accept."

Dr. Trenaman's survey is no source of comfort to those of us who like to believe Britain is a country of well educated, well read, thoughtful people. Some 45 per cent of the population " do not necessarily actively resist learning, but tend to avoid unaccustomed impressions or feel that they cannot be bothered with serious things or are irritated or provoked by them." From his sample of 1,000 people of all ages over 15 interviewed in London and Oxford, Dr. Trenaman draws the conclusion that improvements of educational opportunities since the war have tended to reinforce and extend " the top," not to change the main structure. The important fact, he concludes, is that " fundamental differences of language, knowledge, understanding, concept, outlook and attitude still separate the upper one-third from the lower two-thirds in society," and that there are " obstinate forces of fear and suspicion holding the two apart."

Time and Motion

Putting work study across to staff is a difficult business. It means selling them the idea of change and often counteracting a good deal of prejudice (not always ill-founded) on the use of the stop watch. One of the largest organisations to have gone over officially and wholeheartedly to work study in the last few years has been the British Transport Commission, with its largest interest, British Railways.

The Commission has now issued a booklet called *Work Study and You* to explain simply, and as briefly as possible, the meaning of work study and how it is put into operation. For British Railways there is the added complication these days that a large modernisation programme is going forward and, therefore, the introduction of work study and the effects of modernisation can overlap. This is inevitable but it makes the process of education no more easy. The best time to introduce work study is in times of comparative stability of capital investment or immediately after a big programme goes through—paradoxical as that may seem. If this is not done, and an investment programme is not part of the work study but is running parallel to it and independent of it, work study may have to be done twice and it will be blamed for dislocations and changes for which it is not responsible.

This is a problem which many concerns are faced with as a matter of course. Progress cannot wait for the work-study engineers. The Commission's booklet is a good attempt to get a difficult idea across.

Moving out of Town

The " Moving from London " exhibition, opened last week at Charing Cross by the Minister of Housing and Local Government, was a measure both of partial success and slow progress in getting people to work outside large congested areas. London's problems in this respect are only those of other conurbations but on a larger scale. The new towns in the Home Counties, on Clydeside, and elsewhere, have made a real contribution but much remains to be done. It is in the interests of social progress, industrial efficiency and atomic strategy, that there should be a reversal of the flow of population into big cities.

It must be emphasised however that a thorough going policy of getting factories, offices and people into new towns or revitalised old ones carries with it certain implications about other kinds of investment. Most important of all is a continuation of the road modernisation programme. Old towns without good trunk communications and by-passes are barriers and even death traps. Again, the process of building new towns brings its own problems, not least for ratepayers. New towns at the edge of large old ones probably means a spreading of transport systems and therefore higher costs.

The attraction of young people, especially young married people (for older couples are slower to move) means a large school population and high educational costs. In short, it adds up to higher rates in some communities.

Bulls Unwelcome

Unofficial strikes in the motor industry were a target for Sir Graham Cunningham's rhetoric when he spoke at the annual meeting of Triplex last week. There were, he said, a number of " ignorant and selfish, but often powerful, people " who " go rampant in British industry." He likened them to bulls in china shops—" the longer the brute is left there, the greater the harm "—on both sides of industry. The attitude of employers " who ought to know better " was often inexcusable.

Sir Graham is chairman of the Triplex Group of companies, leading suppliers of windscreens, windows and other glass components to the motor industry. They had been hard hit during their past financial year by an unofficial strike in a motor industry factory upon which many of the car-manufacturing customers of Triplex relied. Triplex factories, where management relationship with employees and trade-union officials was " most cordial " had had to work short time as a result.

Sir Graham went on to say, addressing impartially both employers and employees, that there were no victors in strikes. To resort to a stoppage of work was a confession of failure to be able fairly and reasonably to present one's case, instead of overstating demands and then fearing loss of face through giving way; and to compromise, having seen and understood one another's point of view. The damage that was done by a strike to mutual understanding and confidence between employer and employee was such, said Sir Graham, that " the same beneficial relationships could never be restored."

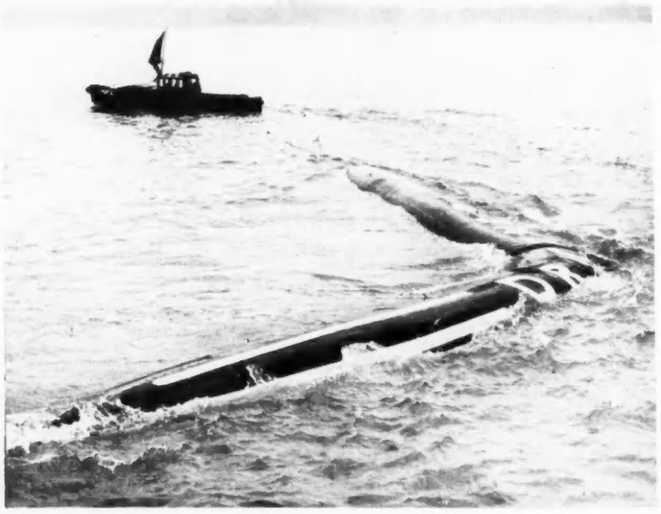
Research and Development

COLLAPSIBLE OIL BARGES UNDERGO SEA TRIALS

NRDC Sponsors Nylon-and-Rubber Towing Tanks

The Dracone flexible and portable oil barge which has recently undergone towing trials in Southampton Water is 100 ft long and 5 ft in diameter. When carrying its cargo of oil, it closely resembles a submarine (minus conning-tower). With a full cargo of 10,000 gallons (approximately 40 tons) of kerosine and towed by a conventional 60 h.p. launch at speeds up to 5½ knots, Dracone D.1. rode silently and smoothly through the water, yielding to the motion of the sea and flexing to the wakes of passing ships. Sharp turns at various speeds fully demonstrated its manoeuvrability, an interesting feature being the way it folded or kinked to enable it to turn in a length much less than its own. The ample strength of the flexible fabric of which the Dracone is made was demonstrated by a student who leaped onto its back from a dinghy and ran to and fro along its length.

A "stressed skin" form of construction has been used. The skin is $\frac{3}{32}$ in thick and consists of a woven nylon fabric coated on both sides with synthetic rubber. The total weight is 2,300 lb, of which the nylon content, which provides the mechanical strength, weighs just over 200 lb. The nose and stern of the container are faired and eyes are fitted for towing or mooring, and for buoys and floats with flags and navigation lights. At the stern there is an Avery Hardoll self-sealing, quick-acting connection for emptying and filling through a 4 in hose. Other connections are provided to enable the internal pressure to be measured. No less interesting than the construction of the container itself, is the design of the stabilising device attached to the stern which

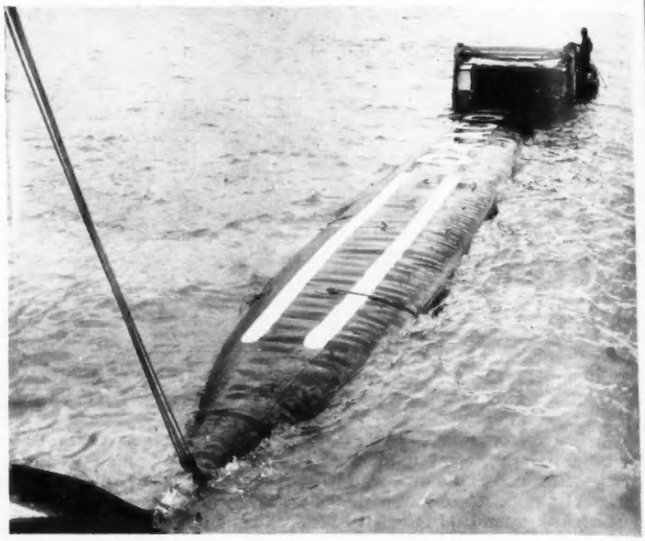


A "Dracone" flexible oil tanker kinks to follow the movements of the launch, thus demonstrating its manoeuvrability.

so successfully prevented the snaking and tendency to yaw which were observed in the early model tests made in the towing tanks at the National Physical Laboratory, Teddington.

The ease with which the Dracone could be discharged and wrapped onto a reel ready for transport was demonstrated at the Dracone Company's base, Marchwood. The time to empty the 10,000 gallons capacity container was about an hour but with more powerful types of pumps, such as are used for emptying tankers, the time could be reduced to about 12 minutes. The reel used for carrying the wrapped-up barge is a squirrel cage 9 ft in length and 5 ft in diameter. For reeling in the water a floating reel with buoyancy tanks was used. The portability of the empty barge when reeled is one of the features of this British invention.

Simple though the idea may seem, its practical application would not have been possible without solving a number of theoretical problems relating to the containment of fluids lighter than water in a flexible skin floating in water. The results showed that existing fabrics could withstand satisfactorily the skin stresses involved. Preliminary trials were made with a model 16 ft in length and 9 in in diameter in the NPL towing tank, and later with a model 67 ft in length and 3 ft in diameter weighing 200 lb and carrying 10 tons of alcohol which was tested on the River Great Ouse, in Harwich Harbour and the North Sea under gale



Dracone being wound on to a floating reel as the contents, 40 tons of kerosine, are pumped out.

and calm conditions. Dracone Developments intend to make further exhaustive tests in Southampton Water and the English Channel.

The rapid progress made in the development of this project—which was originally conceived at the time of the Suez crisis of 1956 by Professor W. R. Hawthorne, F.R.S., Sir Geoffrey Taylor, F.R.S., and Mr. J. C. S. Shaw, all of Cambridge University—has been largely due to financial backing of the Government-sponsored National Research Development Corporation who formed Dracone Developments Limited for this purpose. Dracone D.1—the model currently under test—was made to the design of this company by P. B. Cow and Company Limited. A second flexible barge of similar dimensions is under construction and materials and designs for the manufacture of a 200 ft long Dracone with a capacity of about 300 tons have been prepared. Still larger units of 270,000 gallons (1,100 tons) are envisaged. Provisional data based on a cargo having a specific gravity of 0·85 are given in the Table. The 100 ft (40 tons capacity) Dracone D.1 demonstrated was estimated to cost between £2,500 to £3,000. This compares with the cost of £6,000 for a dumb barge of equivalent (10,000 gal) capacity which requires to be towed back from the discharging point in ballast. A 300 ton capacity Dracone would cost approximately £6,000 and a unit of 1,100 tons capacity, £10,000 to £12,000.

Many are the possible applications of these flexible fabric barges. Although primarily designed for petrol and fuel oil cargo in sea transport, their design can readily be adapted for the transport of other liquids and solids of suitable specific gravity, not only at sea but by inland waterways. They are made sufficiently robust to withstand damage, and if punctured, may be quickly patched in a manner similar to repairing an inflated tyre. Because air is absent in the container there is little explosion risk, and freedom from sparks on impact of the rubber-coated skin material reduces fire risk and since they are not manned, there is no risk to life. More than one unit could be towed in line or abreast thus increasing the efficiency of bulk transport whether of oil, chemicals or foodstuff. Another possibility is that they may be designed for towing submerged, perhaps by atomic powered submarines so that tug-trains across the oceans or by sub-Polar routes may become a commercial possibility.

TABLE.—*Provisional Data for Dracones (Cargo of Specific Gravity 0·85)*

Diameter, ft	5	10	15
Length, ft	100	200	300
Capacity:			
Imperial gallons	10,000	75,000	270,000
Approx. tons	40	300	1,100
Draught, ft:			
Maximum	4	8	12
Normal	3·5	7	10·5
Maximum economical speed, knots	7	10	12
Drag at economical speed, lb	800	6,000	19,000
Drag at 7 knots, lb	800	2,000	3,500
Empty weight, tons	1	4	8

Continuing **Research and Development**

THE AERONAUTICAL SCENE

First International Congress of the Aeronautical Sciences

The application of science to the practical problems of aerial transportation up to the extreme limits of the atmosphere was the underlying theme of the first international congress organised by the International Council of the Aeronautical Sciences and held recently in Madrid. As mentioned last week, the physical arrangements of the congress were excellent, but, mentally, it suffered from overcrowding. Preprints were available for only about half the papers. Altogether, some 45 technical papers were crammed into a six-day conference, which meant paralleled sessions and severely restricted discussions, and very little time for the foreign delegates to get to know their Spanish hosts or to mix with others—which, after all, should be one of the primary purposes of such a meeting. Nonetheless, the organisers are talking of still more papers to be squeezed into the programme for the next congress !

In this first congress, the topics covered ranged over supersonic and hypersonic aerodynamics and propulsion, heat transfer questions and heat-resistant materials, structures and aero-elasticity, boundary layer control, vertical take-off and landing, noise problems of jet engines, navigation and guidance, telecommand and telemetering, and human engineering. We shall not attempt to summarise all the papers here, but propose to pick out points of wide interest.

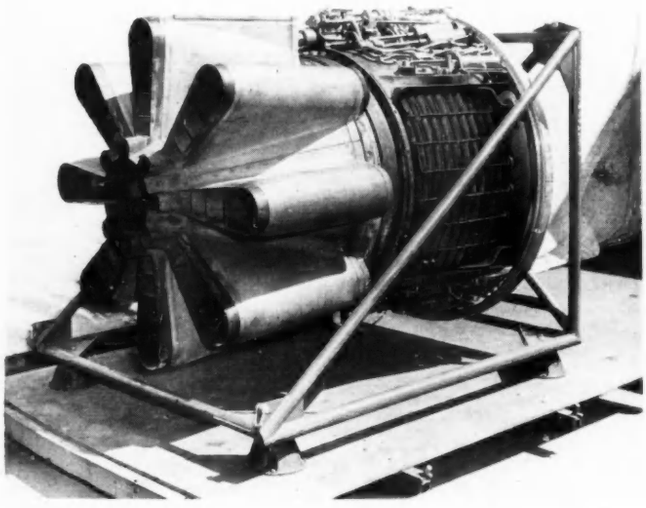
Noise

Thus the subjects covered ranged from here-and-now problems to those of the fairly long-term future. Among the former was the highly topical question of aircraft noise—and particularly of jet-engine noise—with contributions from four countries: Great Britain, the United States, Canada and France. The problem of making jet aircraft operation acceptable to residents near airfields, although it will be simplified by the adoption of the low jet-velocity engine—the bypass engine—can only be overcome for high-thrust engines by adding weight and drag to the aircraft. The method of silencing the jet is to cool it rapidly by inducing a cold air flow; and an upward shift of frequency renders the noise less offensive. The use of multiple-ejector nozzles has been found, both in the United States and in Great Britain, to be the most effective means of achieving this end. Either multiple tubes, as in the current Boeing 707 installation; multiple lobes; or corrugated nozzles, as favoured by Rolls-Royce for their Avon and Conway power plants, are employed. A typical Conway suppressor, as will be used in the Boeing 707, is shown in the illustration on this page.

One rather surprising suggestion was made in respect of aircraft flying at supersonic speeds at low altitudes. To protect airports from the, blast waves thereby generated, it was proposed that administration, passenger reception and maintenance buildings could be located underground. What would happen, in such circumstances, to the unfortunate people living locally was left to the imagination.

There are, of course, many other aspects of aircraft noise which demand consideration—and one interesting point put forward was that, with the modern jet-engine airliner, where the cockpit is placed well forward of the engines, it may, in fact, be too peaceful, as the steady quiet hum of the engines may have a soporific effect on the crew.

Another vital aspect is the question of structural fatigue resulting from jet efflux noise, which can set up resonant vibrations in skin panels. Tests undertaken by Avro Aircraft Limited, Canada, show that failures tend to occur at joints and in the skin through rivet lines. Effective means of increasing the life of the components are to reduce the panel size, to introduce doubler plates and to provide additional damping.

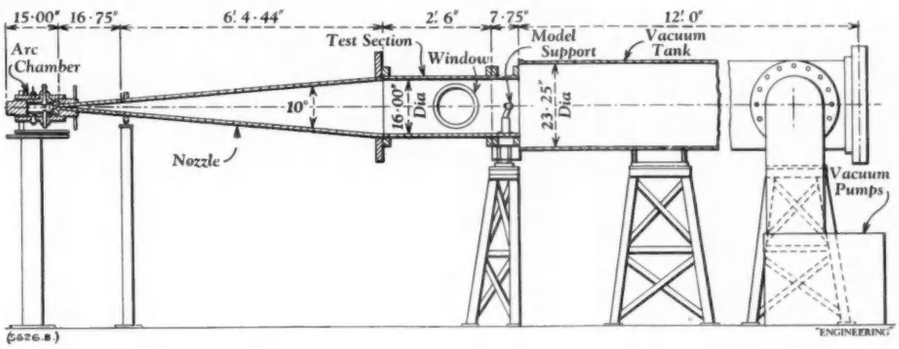


Silencing nozzle and thrust reverser developed by Rolls-Royce for the Conway engine installed in the Boeing 707-420.

Hypersonic Flight

The problem of flight at hypersonic speeds—many times the speed of sound—is to-day the subject of much theoretical and experimental study. Hypersonic flow is complicated by the fact that the fluid behaves as a non-ideal gas with variable properties, as it may dissociate or undergo chemical and physical changes in limited regions of the flow. In spite of these difficulties, rapid progress has been made and it seems that results to date tend to indicate that, for a high flight Reynolds number, real gas effects are of relatively small importance. Pressure distributions and forces on simple boundary conditions can be obtained with simple rough approximations which are often sufficiently accurate for engineering applications. The heat transfer on simple bodies can be obtained with good approximation for the laminar case on existing theories, and simple theories for turbulent flow seem to give sufficient approximation. Transition phenomena and the foundation of turbulent analysis, however, require much further study. Entropy gradients appreciably affect heat transfer and can be used to reduce aerodynamic heating at high speeds.

On the experimental side, new " tools of the trade " for hypersonic flight investigations include the development of electric-arc-driven Hotshot wind tunnels. The first of these, with a 16 in diameter, gave



General layout of the 16 *in diameter Hotshot wind tunnel.*

Continuing Research and Development

simulated conditions of 160,000 ft altitude and 15,000 ft per sec velocity, with a flow duration of up to $\frac{1}{20}$ second, enabling measurements of heat transfer rates, pressures and forces to be obtained. The general layout of this tunnel is shown in the drawing on the previous page. The second Hotshot tunnel, now under development, has a 50 in diameter, and larger installations will probably be developed. In principle, the tunnel consists of an arc chamber separated by a diaphragm from a 10° conical nozzle attached to a cylindrical test section and a cylindrical vacuum tank. Initially, the arc-chamber is filled with air at moderate pressure, up to 130 atm, and at normal temperature, while the rest of the tunnel is evacuated to a low pressure of about 1 mm Hg. Stored electrical energy is discharged in an arc inside the arc chamber, causing a rapid rise in the temperature and pressure of the air, and disintegrating the diaphragm. Following the initial unsteady phase of flow, a quasi-steady flow is established in the nozzle and test section.

Another development is the plasma jet, in which the working fluid does not resemble air. This, too, has an electric-arc drive and is capable of producing high enthalpy flow. The original German water-stabilised arc produces a mixture of dissociated and ionised oxygen and hydrogen. More recently, arc-powered air jets are being developed. For continuous operation, the power requirements are large and the problem of throat erosion becomes correspondingly difficult with the increasing density.

At the Arnold Engineering Development Center, the electric-arc method is being applied to the development of hyper-velocity guns, in the belief that much higher gas temperatures, and hence, projectile velocities, can be obtained, probably of from 30,000 to 40,000 ft per sec. Many problems, however, such as gun-barrel erosion, have still to be solved. When this is accomplished, the hyper-velocity gun may be applied, in conjunction with a supersonic nozzle, for trajectory simulation and the practical investigation of re-entry on a model scale.

Heat Transfer

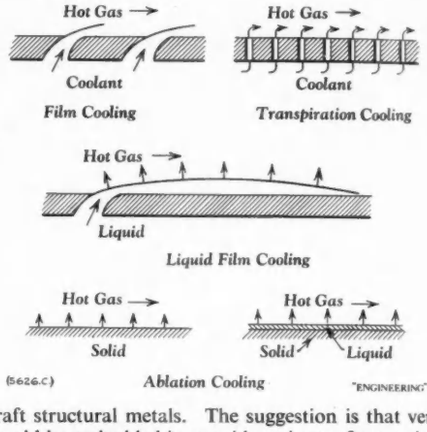
Closely allied to hyersonic-flow investigations are heat-transfer problems, and contributions on this subject came from Spain, the United States, France, Germany, and Great Britain. In hypersonic flight, an aircraft is surrounded by a layer of hot air, generated by adiabatic compression ahead of the vehicle and friction along its sides. The resulting heat flowing into the aircraft skin, apart from that which is removed by radiation—often only a small fraction of the total—has to be absorbed by a heat sink. This may be either a solid material, or one which melts and evaporates, or sublimes, or chemically decomposes in absorbing the heat.

If the material of the heat sink is transformed to vapour, it has to be discharged from the aircraft, and this process can be done in such a way that it generates a mass flow away from the stem, thereby helping to reduce the heat flux into the skin. This is known as mass transfer cooling. In the film cooling process, the coolant gas or vapour is discharged downstream through a series of slots. More efficient is the transpiration cooling process, in which the coolant gas is blown through a porous surface. Most effective are the lightweight gases, hydrogen first and then helium. In the liquid-film cooling process, the coolant is discharged through slots to form a continuous film over the outside surface, whence it evaporates into the hot-gas stream. The heat-sink material can also be applied on the outside of the skin; sublimation, decomposition or melting starts as soon as the surface reaches a certain temperature. This process is known as ablation cooling, and an interesting film was shown at the congress of tests on ablation-type blunt-nosed cones heated to 10,000 to 20,000° C in a plasma jet. A surprising feature was the good performance of a nylon cone in comparison, for example, with metal cones—copper or stainless steel. This is an indication of the effectiveness of the mass-transfer cooling process from the nylon cone surface. Graphite showed up even better.

Materials and Techniques

Where a heat sink is utilised without mass transfer cooling effect, graphite again shows up well, from the point of view of the weight of material necessary to stand up to heat without melting; and so does beryllium. A particular example quoted equivalent wall thicknesses of $\frac{1}{4}$ in (graphite), $1\frac{3}{4}$ in (beryllium) and 2 in (copper), corresponding to weight ratios of 1 : 24 (graphite : copper) and 1 : 6 (beryllium : copper), respectively. However, graphite has low strength and oxidises easily; and beryllium has low ductility.

The possibilities of beryllium have also been cited in connection with structural uses, because its stiffness is some six times greater than the



Mass transfer cooling methods.

conventional aircraft structural metals. The suggestion is that very thin beryllium wires should be embedded in epoxide resin, to form reinforced plastics with nearly double the strength and five times the stiffness of an aluminium wing of equal weight. Economically, this seems doubtful.

In gas-turbines, blade cooling to cope with higher turbine inlet temperatures is increasingly favoured. A method for producing the fine longitudinal cooling holes (of some 0·06 in diameter), that is showing very fair promise is deep-hole drilling by spark-machining techniques, which is only applicable, however, to straight holes. Where the cooling holes require a curved contour, one method is to form the holes in a simplified blade form, to fill them, and then to forge them to the final shape required. The filler wires are then etched away by acid treatment. After prolonged development, a high quality pre-alloyed atomised powder for pressing and sintering is now available for the fabrication of complex blade shapes with "built-in" cooling ducts. Possibly the next step—some way ahead—will be porous components which can exploit the advantages of transpiration cooling.

(*To be continued*)

MARINE GAS TURBINES

Although the gas-turbine design section of the Parsons and Marine Engineering Turbine Research and Development Association suffered acute disappointment when work was stopped on the design of a 3,000 s.h.p. gas-turbine for a dry cargo vessel, the effort expended on the project was by no means fruitless.

The design had progressed to a stage where a number of detail drawings had been produced and forging sketches of the turbine rotors had been issued. Among the problems overcome was the complete redesign of the turbine castings to avoid infringing existing patents, the turbines being designed for end assembly with no horizontal joint in the main casings.

The design speed of the six-stage high-pressure turbine driving the 20-stage high pressure compressor was 8,000 r.p.m.; that of the overhung two-stage low pressure turbine driving the 14-stage low-pressure compressor was 6,500 r.p.m. Under these conditions the overall pressure ratio was 11·9 : 1, and with h.p. and i.p. turbine inlet temperatures of 1,250° F, the maximum design power was 3,500 s.h.p. An intercooler of 85 per cent effectiveness between the two compressors and a 70 per cent effective exhaust heat exchanger were estimated to give a main engine specific fuel consumption of 0·46 lb per s.h.p. hour, based on fuel with an l.c.v. of 18,500 B.t.u. per lb.

The design of a compact compressor inlet volute was put in hand and it is hoped that the results of model development by the aerodynamics section of the Association will enable a standard procedure to be laid down. A method of designing twisted turbine blades with a view to ease of manufacture was evolved. A new turbine nozzle profile was designed, and was found in cascade tests to have a low loss coefficient and a useful incidence range of at least 80°.

The Pametrada *Progress Report* of 1957 records that during the year four specific inquiries were received for turbines to operate with free piston gasifiers. The power of the installations ranged from 3,000 to 6,000 s.h.p. and the gas-turbine design section has been consulted in connection with a number of others up to 7,000 s.h.p. Owing to the difficulties associated with operating gas-turbines with astern elements under atmospheric exhaust conditions, there has been mounting interest in the use of unidirectional turbines with hydraulic reversing transmission, and a number of such schemes have been put forward. The turbine designs have so far been based on standard steam turbine blading, but a range of turbines is now being designed to incorporate the new nozzle profile referred to above, with a rotor blade profile specifically designed for free piston installations. This will approximately double the power from a given size of turbine, compared with the present design.

FLIGHT TESTING GAS TURBINES ON THE GROUND

Conditions of Dive and Climb Simulated in Rolls-Royce Facility

THE final tests of any aircraft must be made in flight, but there are many factors that can make flight testing a long drawn-out affair, not least among them being the weather. Moreover, the equipment that can be carried on test flights is limited and so, to some extent, is the recording of results when an aircraft is airborne. Accordingly, any arrangement by which some part of an aircraft can be tested under operational conditions on the ground offers a saving in time and money, and, possibly, in safety for the pilot. One part which immediately springs to mind in this connection is the engine; know your engine performance under all conditions, and any failure to attain the designed results can fairly be ascribed to the airframe.

For this purpose, therefore, Rolls-Royce Limited have constructed at their Sinfin works at Derby a test house in which turbojet and turboprop engines can be tried out under any altitude conditions likely to be met with in civil or military service. Heights of up to 70,000 ft can be simulated and Mach numbers up to 2·5 can be reproduced for any height above 36,000 ft. The plant is capable of testing any existing engine as well as any envisaged during the next few years. There are two test cells, of which only one is normally in use at any one time.

Fundamentally, the plant consists of two sets of air-treatment equipment housed in two main buildings. The first set supplies air at the selected conditions to the intake of the engine, while the second set handles the exhaust and creates the altitude conditions in the test cell. In addition, the first set can be used to supply cleaned air to an adjacent compressor test rig in which there is an air turbine of 15,000 h.p. for driving the compressors under test, and which is fed from the exhauster/compressor. The plant is capable of supplying up to 200 lb of air per second at any temperature from − 90° C to + 190° C, and at any pressure at the engine intake from 1 to 55 lb per sq. in abs. The original plan included a wind tunnel, but this was cancelled as a result of the Government's recent decision on the aircraft industry. Provision has been left on the site, however, for the tunnel to be added at a later date. A diagram showing the general layout of the site, Fig. 1, is reproduced below.

INPUT PLANT

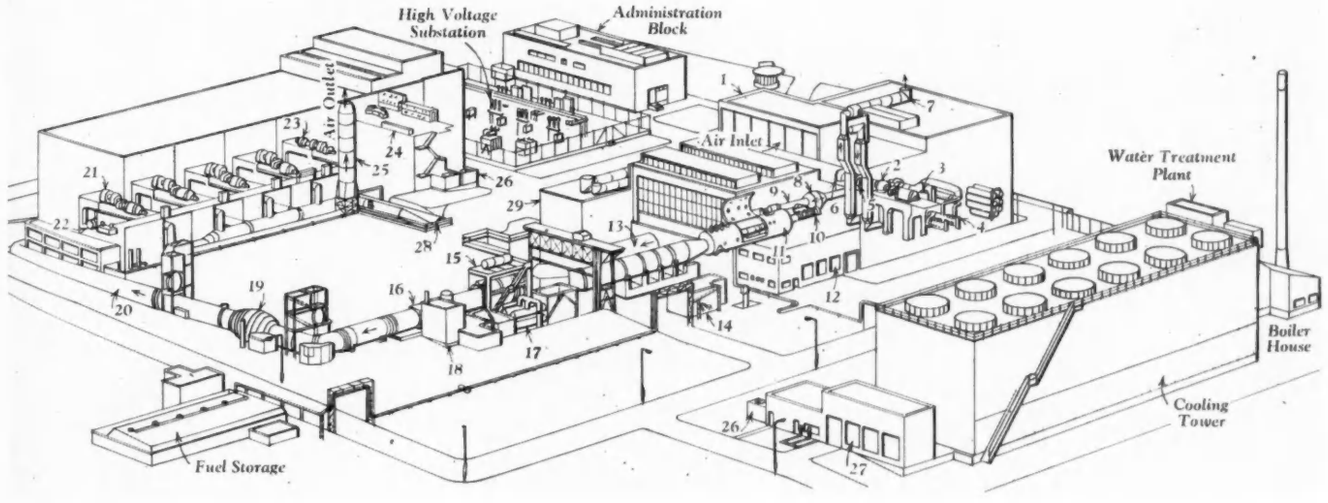
Air for the plant as a whole has to be cleaned, dried and temperature-conditioned to obtain the desired working conditions. Fig. 2 is a diagram of the building and shows the operating circuit. Air is drawn in through Cullum splitters and Sturtevant Precipitron electrostatic filters by a Brown-Boveri compressor, which is driven at 4,150 r.p.m. through step-up gearing by a synchronous 22,000 h.p. motor; both motor and gearing being supplied by the same firm. The compressor has eleven stages of axial flow and an overall ratio of 3·8 to 1. On the same shaft as the compressor are a recuperating turbine and an air-cooling turbine, both of which help to relieve the power demand.

The air leaves the compressor at 55 lb per sq. in abs. and at about 190° C, and passes through a water-cooled heat exchanger, an ammonia refrigerating plant, a water separator and a chemical drying plant, all of which can be by-passed to give the higher temperatures by mixing. The Sterne ammonia refrigerator reduces the temperature to 2° C, at which most of the water can be removed by mechanical means. After leaving the Silica Gel dryer, the temperature rises to about 8° C. When it is desired to operate at temperatures lower than this, the air is allowed to expand through the cooling turbine already mentioned, which is a two-wheel single-stage machine having a maximum flow of 160 lb or air per second and giving a minimum outlet temperature of − 104° C. As already stated, this turbine is connected to the main drive shaft so that the work done during the expansion of the air can be used, at least in part, to reduce the power drawn from the main motor. The compressors and turbine sets, it may be mentioned, were all supplied by Brown-Boveri.

The treated air, having reached the required operating conditions, can be fed to either of the two test cells or to the plenum of the compressor test rig in the adjacent section of the building. The ducting has been kept as short as possible to reduce the heat mass in order that conditions can be altered with a minimum of delay—an important factor in making full use of the plant. All ducting that is subjected to the lower temperatures is made of stainless steel, in accordance with the requirements of the pressure-vessel code. The ducts are also fully lagged and in no part does the flow rate exceed 0·1 Mach. When the air requirements of the engine are less than the output of the plant, the excess is fed through the recuperating turbine, and the power so generated used to relieve the drive on the compressor shaft. This turbine also is a two-wheel single-stage machine. If desired, it is possible to augment or replace the input compressor supply by drawing in direct from the atmosphere or from the exhauster building.

The mixing of the air from the two streams, to obtain the desired engine intake conditions, takes place in a chamber made of stainless steel, which is constructed along the general lines of Rolls-Royce combustion chambers. The whole intention is to obtain a uniform mix of air in as short a length of ducting as possible, so that the conditions do not alter along the line and so that the time lag due to heat mass, when changing from one test condition to another, is kept as

Fig. 1 The testing of gas turbines involves the handling of large quantities of air. The Sinfin plant can deliver (and extract) up to 200 lb per sec at from 1 to 55 lb per sq. in abs. and temperatures from − 90° C to + 190° C.



1. Electrostatic air intake filters.
2. Input compressor.
3. Cooler for input compressor.
4. Refrigeration plant.
5. Recuperation turbine.
6. Cooling turbine.
7. Silencer for recuperation turbine exhaust.
8. Mixing box.
9. Cell intake pressure control valves.
10. Dynamometers.
11. Altitude test cell.
12. Preparation shop.
13. Diffuser duct.
14. Spray water pumphouse.
15. Primary cooler.
16. Cell pressure control valve.
17. Heat exchanger.
18. Primary cooler pumphouse.
19. Secondary cooler.
20. Main exhauster duct.
21. Exhauster compressor.
22. Cooler for exhauster compressor.
23. Recuperation turbine.
24. Main control room.
25. Main exhauster silencer.
26. Transformers.
27. Cooling water pumphouse.
28. Cross over duct input/exhauster buildings.
29. Compressor test rig.

Continuing Research and Development

short as possible. A by-pass circuit is common to both cells and allows sudden changes in air demands to be met. One example of such a change would be in the simulation of a dive or a climb, both of which it is hoped to reproduce accurately, or even when starting the engine. For such tests, the air supply would be set to the anticipated maximum and the excess at any time bled off through the by-pass; the valving is arranged so that closing the by-pass opens the cell intake simultaneously, and the overall air demand is thereby maintained constant.

Before each of the altitude cells proper there is a plenum chamber, in which the air flow is straightened, and the pressure and temperature are measured. The air also passes through a debris-removal screen to save any possible damage of the engine or instruments. Through the bulkhead separating the plenum chamber from the cell, there passes the airmeter which measures the flow; the thrust of the air on this must be accurately known so that the net thrust of the engine can be determined from the dynamometer readings.

The two cells are not quite identical in construction as one is intended for turbojet engines, and the other for turboprop or turbojet types. Consequently, the latter, to allow space for a dynamometer shaft, has provision for side entry of the air, while the former is arranged for end entry only. In both cases, the air meter connects direct to the engine intake, as may be seen from Fig. 2, which shows an engine in place in No. 1 cell. There is no leakage of air between the meter and the engine for obvious reasons. On the other hand, there is leakage between the exhaust tube and the exhaust duct, the amount of which determines the pressure in the cell. To obtain this, the exhaust of the engine discharges into a flared tube and the gases are extracted by the exhausters in the second building. The exhaust tube is water cooled.

In all test plants, a great deal of time can be spent in the setting up and dismantling of the item to be tested. Since this process is obviously so much time lost, it should be cut to a minimum and, at the Sinfin works, considerable pains have been taken to do this. Below each of the test cells (which are at first floor level) there is a preparation room in which the engines are prepared for testing. The process includes completing assembly where the engines have been received in parts, and preparation for mounting on the bed, such as bringing out temperature and pressure test points. In each test room there is a trap-door in the floor, through which the engines are hoisted and which can be closed and locked when tests are in progress. The door of the altitude chamber can be opened, as shown in Fig. 3, by the hoist (it weighs about 16 tons and is counterbalanced for ease of movement) and the engine lowered directly on to the bed; it will already have been mounted on a dolly in the preparation room. This dolly carries all the connections for the manometers and electrical circuits. Thus, when the engine is placed in the cell, there is little tedious connecting up of terminals. The dolly forms part of the cradle when the engine is installed.

The Heenan and Froude thrust bed on which the engine rests is of the suspended type and transmits the engine thrust mechanically to direct-reading weighing machines. As already mentioned, allowance has to be made for the thrust of the air against the airmeter as this also is transmitted to the bed. The weighing machines are in the operating room on the floor above the cells, from which the assistant controller and the engine running staff can view progress. The manometer and thermometer connections (there are some 200 of each) are also taken to the operating room.

Access to the engines is provided by an airlock as well as by the main door (which is 20 ft long) and through which the engines are introduced. One of the hazards to be faced is that of explosion, and in the exhaust-extraction duct there are water spray nozzles in addition to the external water-cooling arrangements already mentioned. The duct itself is so designed as to obtain some measure of pressure recovery to assist the exhausters and so extend their useful capacity. Cell No. 1 has now been in use for about 200 hours, while cell No. 2 is expected to be commissioned before the end of the year. The running time so far achieved indicates that the target of 2,000 test hours per annum for the complete plant should be fairly easily reached.

The exhaust ducts from the cells are water jacketed for 143 ft after leaving the building, and, in this length, have removable sections that can be replaced by solid bulkheads to shut off the cells from the rest of the system. These bulkheads are necessary for isolating the cells because the two ducts feed a common primary cooler, and thereafter run in one combined duct through the butterfly valve that regulates the pressure in the cells, and the secondary cooler to the exhauster house. The wind tunnel envisaged in the original plan was to have been placed between the two buildings and accounts for the apparently unnecessary shape of the ducting. After the secondary cooler there are two sets of tappings for the wind tunnel, complete with their bulkhead sections, which were allowed to remain so that they would be ready in the event of being able to construct the tunnel at a later date.

The compressor test rig, which is housed adjacent to the input (air treatment) plant, assists in maintaining the high utilisation of the whole plant. Two of the exhaust compressors in the exhauster house can be compounded to provide air at a pressure of 155 lb per sq. in and a temperature of 200° C for driving the 15,000 h.p. turbine. The latter is used to drive the compressors under test, which draw a supply of cleaned air from the plenum chamber of the input plant. The turbine has a speed range from 3,000 to 11,000 r.p.m. and there is a torque meter mounted in the drive to the test compressor. To assist further in making the fullest use of the plant, a pipeline has been laid to a neighbouring site where there is a combustion laboratory.

(To be continued)

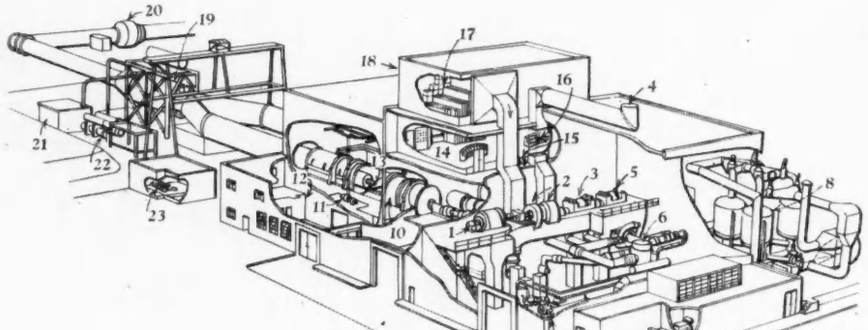


Fig. 2 (above) To obtain the required test conditions, the air is cleaned and dried, cooled by refrigeration and expansion, and metered to the engine intake.

1. 22,000 h.p. motor.
2. Input compressor.
3. Recuperating turbine.
4. Turbine exhaust silencer.
5. Cooling turbine.
6. Water cooled heat exchanger.
7. Condenser.
8. Drying plant.
9. Transformers.
10. Test cell.
11. Engine.
12. Engine preparation shop.
13. Slave jet pipe.
14. Control room.
15. Controller.
16. Engine tester.
17. Precipitators.
18. Air intake.
19. Primary cooler.
20. Secondary cooler.
21. Pumphouse.
22. Heat exchanger.
23. Spray water pumps.

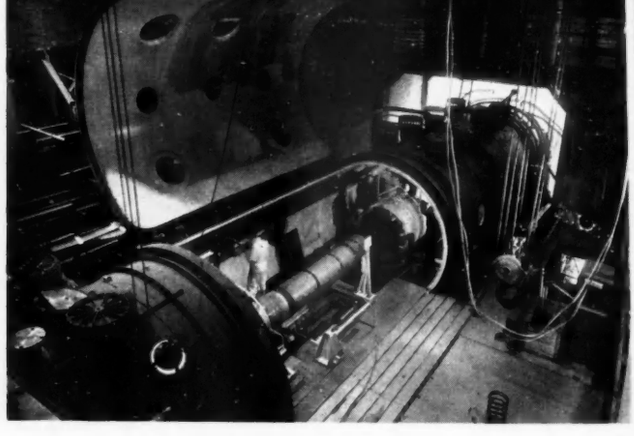


Fig. 3 (right) In the altitude cell the engine is mounted on a bed which measures the thrust. A butterfly valve in the exhaust line regulates the altitude conditions.

Book Reviews

CAUGHT UP IN TECHNICAL CHANGE

Productivity and Social Organisation: The Ahmedabad Experiment. By A. K. RICE. *Tavistock Publications Limited, 2 Beaumont Street, London, W.1.* (35*s*)

This is an important book for engineering managers, who should not be put off either by the fact that it is a report on operational research in an Indian cotton mill or by the novel concepts on which the research was based. Clearly written, with little of the jargon too frequently used in works of this kind, it makes a serious contribution to the problem of achieving technological change, whether in a traditional or an industrial society, and to the problems of management associated with it.

The author, who was once a personnel manager in the engineering industry, is now a senior member of the research staff of the Tavistock Institute of Human Relations. The work here reported was carried out in an old established mill in one of the textile districts of the State of Bombay. Three problems were dealt with: the re-organisation of an automatic weaving shed; the improvement of efficiency and quality of weaving on non-automatic looms and the re-organisation of a traditional management structure to one more suited to a complicated industrial undertaking employing eight-thousand workers. Among other difficulties in the situation were the special laws governing the discipline and discharge of employees and a national campaign waged by the trade unions against rationalisation arising from the fear that it might increase the already appalling unemployment that exists in India.

The principle behind this work is that technological change always involves changes in social organisation, which need even more careful preparation. The author emphasises the necessity, before introducing any change, of a clear definition of the primary tasks being performed by each worker and manager and of the roles which they play in carrying them out. The roles include not only those which are obviously connected with the tasks and recognised by official titles, but others which derive from psychological and social needs, and each worker may have to function in several roles at once.

Workers who have been used to working in small family groups will not be most productive if given individual tasks, especially if they are not tasks complete in themselves. Resistance to change will be lessened if work can be organised in groups of a certain size within which permissive and collaborative relationships can be formed. In the case of the automatic loom shed, reorganisation on these lines was quickly accepted. The main feature of the change was the recognition that the old title of " weaver " was inappropriate for an automatic system, and that the ancillary workers were as much part of the productive group as the weaver, whose main task nowadays is to mend broken warp threads and to keep the looms running.

In the case of the re-organisation of the non-automatic shed, the problem was to change from an inefficient two-loom system, based on low wages, to a system using four looms with warp stops. The latter had been opposed because they involved extra work. Under the old system, also, the payment system encouraged the weaving of damaged cloth. In this case the change was effected after the workers confidence had been gained during consultations while the looms were stopped. This led to useful suggestions and the actual form of group organisation was finally chosen by the workers themselves.

There was the usual reluctance to change the informal management structure with its close personal relationships, based on family ties, with the head of the firm. Moreover these relationships were supported by Indian family traditions. Before change could take place it had to be recognised that they involved the managing agent, corresponding in function to a chairman and managing director, in a confusion of roles. It was difficult for him to separate his role as general manager, controlling and guiding subordinate managers, from an executive role, in which he played an inevitably dominant part in their own executive decisions. Management was re-organised so as to recognise the several levels of command and each differentiated function was recognised and located at its appropriate level.

In a final chapter the author attempts to evaluate his work and discusses whether the methods he used would be of universal application. His conclusions are commendably modest and he emphasises the part played in group attitudes by differing social customs. Nevertheless, the general principles on which he undertook his preliminary enquiries would seem suited to most industrial situations.

One of the virtues of this book is that it throws a fresh light, based on empirical research and not on hypothetical reasoning, on the theoretical conception of management. Everyone concerned, whether with the implementation of change or with the development of appropriate management structures, will find here ideas which are both stimulating and immediately fruitful.

NEW BOOKS

Maintenance of Mechanical and Electrical Parts of Public Health Equipment. *National Coal Board, Hobart House, Grosvenor Place, London, S.W.*1. (5*s* 6*d*)

All mechanical and electrical apparatus which is part of public health engineering equipment must be examined and maintained systematically. The present publication is divided into three sections, dealing with water treatment plant, sewage treatment plant, and pumps, respectively, and describes, under headings for each type of plant, the work which should be done at stated intervals.

A Practical Guide to the Design of Steel Castings. *British Steel Castings Research Association, East Bank Road, Sheffield* 2. (12*s* 6*d*)

This is an English edition of the guide originally prepared by the Commission Technique de la Metallurgie des Aciers of the Centre Technique des Industries de la Fonderie, Paris. It gives information on the properties of cast steel, foundry defects due to bad design of castings, and design rules independent of the direction of moulding and pouring. It is well illustrated with line diagrams.

The Calculation of Load and Torque in Hot Flat Rolling. By P. M. COOK and A. W. MCCRUM. *The British Iron and Steel Research Association, 11 Park Lane, London, W.*1. (65*s*)

The book contains the results of five years' work at BISRA's Sheffield laboratories in determining stress strain curves for steel in compression at temperatures up to 1,200° C and over a range of deformation speeds usually met with in working practice. It describes the method and contains the data for calculating the load and torque for twelve steels. 96 large graphs give the necessary mean yield strength data for these steels at 900, 1,000, 1,100 and 1,200° C over a range of strain rates and reductions covering all industrial requirements. Other graphs are provided from which the strain rate and geometrical functions associated with any particular operation can be rapidly calculated.

Oral Communication of Technical Information. By ROBERT S. CASEY. *Reinhold Publishing Corporation, 430 Park Avenue, New York 22, N.Y., USA.* (4·50 *dol*); and *Chapman and Hall Limited, 37 Essex Street, London, W.C.*2. (36*s*)

The author attempts to present methods of effective speaking for various occasions. Beginning with the bridges and barriers to effective communication he then considers the problems involved and how they are to be solved: organisation of material; composition; delivery of formal and impromptu speeches; and the use of mechanical aids such as recordings and slides; presiding at meetings; talking science to laymen; presenting technical legal testimony and social conversation.

On the Shelf

By Frank H. Smith

One does not often have evidence that the scientific societies try to educate their members in the value of information sources. Perhaps they assume that it is part of graduate training; but how many graduates receive, as part of their education, an insight into the use and working of a library ? It is a pleasant surprise, therefore, to see, in the *Journal* of the Junior Institution of Engineers for August, a paper by Eugene Gros on " Making Use of Russian and Czech Scientific and Technical Information." At least one prominent technical society has recently appointed a public relations officer, but more could, perhaps, benefit from Mr. Gros's closing sentence—" I believe we can learn a lot from the Russians in the field of presenting the technical world to the general public."

Historically minded readers may like to know of " The Lunacy of Railways " by Marjorie Whitelaw. This is a delightfully illustrated article in the *Hunting Group Review* (Norwich House, 4 Dunraven Street, London, W.1) No. 3, 1958. Which reminds me that a small paragraph in *The Times* recently announced that the famous Hulton Picture Library (formerly the Picture Post collection) has been acquired by the BBC. The Library is still available as it was under its original administration.

The publicity game has always greatly intrigued me—in fact you could call me a publicity agent *manqué*—and I accordingly found an article on " Domestic Detergents " in the August *Research* most interesting. This gives the background of the whole washing powder business with figures of advertising costs, percentage hold of the market, and so forth.

I am indebted to Professor Hartenberg of Northwestern University for calling my attention to SAE Preprint 54A on " Symbiotic Interaction between Science and Engineering." Look up symbiosis (if necessary) and you will appreciate " the raw material supplied by science plays the same role for the engineer as do words for the poet. He combines them into a new unity with a content far transcending that of the individual building blocks." This is how the author, a Mr. Gerhart Groetzinger, puts it, but I think the Oxford Concise definition of symbiosis puts the relationship 'twixt science and engineering even better: " Permanent union between organisms each of which depends for its existence on the other as the fungus and alga composing lichen."

Griffin, 42 Drury Lane, London, W.C.2, list three titles in their Statistical Monographs and Courses (edited by M. G. Kendall) and the leaflet giving particulars has ten other titles on the same subject on the back. Statistical titles tend to be a bit long so perhaps you will write and get the leaflet for yourself?

Self-Changing Gears Limited, of Lythalls Lane, Coventry, are building up a mailing list for their forthcoming house journal to be called " Transmission Times " (no relation to Radio Times which are different transmissions). It will appear quarterly and readers wishing to have this addition to the literature on road, rail and marine transmissions should write to the Editor, at the address quoted.

On 25 July, I mentioned SINTO, the interchange scheme which operates on Sheffield as a centre. A proper pride has prompted the Librarian of Kingston-upon-Hull (Central library, Albion Street) to send me details of a similar scheme centred on his Commercial and Technical Library. The qualification for membership of the scheme is 25 books and three current periodicals. I do think this " bungle 'of faggots " idea for information pooling is first-class and one must hope that the idea will spread to all cities and their environs. Despite that small requirement of three periodicals, Hull can muster 1,100 different periodicals, I repeat—*different*.

Metals and Materials

ULTRA HIGH TENSILE STEEL

Properties and Applications of a New British Material

By L. Marshall, A.I.M., A.F.R.Ae.S., A.I.MECH.E., *and H. Beresford*

In view of the continued development of the ultra-high-tensile steels as structural materials by the American aircraft industry, increasing interest is now being taken by British designers in their properties and design potentialities. This interest has initiated an immediate and active response on the part of the British steel manufacturers, and investigations covering the basic metallurgical properties of these new steels together with their fabrication and design aspects are now in progress. It is too early to say what the final outcome of these investigations will be in terms of an approved steel which is generally acceptable for use in aircraft structures. Sufficient work, however, has now been carried out in this country to show that the American claims are well justified and that such steels should be a practical possibility for aircraft and other engineering structures where a high strength/weight ratio is required. This article is intended to review specifically a new steel which shows high promise of meeting—without undue loss of ductility and toughness—the designation "ultra-high-tensile." It also reports on incidental work carried out to assess the relative merits of copper and nickel/phosphorus plating as a means of preventing decarburisation during heat-treatment without giving rise to subsequent hydrogen embrittlement. These steel have found immediate favour in the United States, and a number are now in use for design purposes. An existing, conventional type of steel to specification S.A.E. 4340 has also been further developed to meet these higher tensile requirements and certain components in this material have been flight tested by the Lockheed Aircraft Corporation.

Some two years ago in this country there was only limited experience of the steels in question and then only in so far as the properties claimed for them had been reproduced in test pieces obtained from small laboratory melts. It was therefore decided that a more realistic approach on a broad production basis was necessary if the introduction and development of these steels for engineering design purposes was to be successfully effected. After an independent survey of British and American ultra-high-tensile steel compositions and properties, it was decided that the composition designated Rex 539, developed by Thos. Firth and John Brown Limited, Sheffield, offered the most immediate promise of design utilisation. Therefore, as a starting point, a 10 ton cast of steel was made and broken down into bars and billets, with a view to the production of tubes and forgings, the latter being intended for specific design studies in connection with aircraft components.

COMPARISON OF REX 539 AND OTHER STEELS

As a preliminary step in the investigation, a brief examination was made of the tensile/tempering temperature and Izod/tempering temperature characteristics of this steel in order to see if it were in fact superior to some of the quoted American steel compositions. Rex 539, was therefore compared with two current American ultra-high-tensile steel compositions and also with one standard British steel composition B.S.S.96. For comparison these compositions are quoted in Table I, together with that of S.A.E. 4340. Comparing the conventional 2½ per cent nickel-chromium-molybdenum steel, represented by the S.96 composition, Fig. 1 shows the superiority of Rex 539 in terms of tensile and proof stress values. Over the 250/450° C tempering range there is the usual pronounced temper brittle dip in the case of S.96 steel. The Rex 539 steel gives a more uniform response to tempering with regard to Izod values over this range. Generally speaking, for tempering temperatures above 350° C the 0·1 per cent proof stress for Rex 539 is almost as high as the ultimate tensile stress for the S.96 composition.

Fig. 2 shows the tensile/tempering temperature and Izod/tempering temperature characteristics of Rex 539 and compares them with similar graphs established for steel of composition "A," an earlier American ultra-high-tensile steel composition. From a consideration of the graphs, the Rex 539 would appear to be superior to steel "A," since a high tensile value can be obtained without an undue lowering of tempering temperature. A tensile strength in excess of 120 tons per sq. in can be obtained by tempering at 350° C and 100 tons per sq. in proof stress is still possible even if the tempering temperature is increased to 390° C. The fact that these values can be obtained at such high tempering temperatures is important from a number of aspects which are listed later. The high tempering temperature is made possible by the fact that Rex 539 does not exhibit a temper brittle dip in this tempering range. The proof/ultimate stress ratio at 120 tons per sq. in for Rex 539 is 0·86. The proof/ultimate stress ratio for any significant tensile value of the order of 110 tons per sq. in is considerably lower in the case of steel "A" (0·73). The tensile/tempering temperature and Izod/tempering temperature characteristics of Rex 539 are compared with those of steel of composition "B" in Fig. 3. From a consideration of these graphs, Rex 539 appears to be superior to steel "B" particularly as regards the 0·1 per cent proof stress. There is, however, little to choose between them as regards Izod and elongation values for any significant temperature above 300° C. Steel "B" at 110 tons per sq. in shows a higher proof/ultimate stress ratio than steel "A," but Rex 539 is superior to both in this respect. There appears to be a pronounced peak in the ultimate and 0·1 per cent proof values for Rex 539 over the tempering temperature range 300° to 400° C; possibly this could be made use of to obtain maximum properties concomitant with reasonable Izod and elongation values. It was decided following these tests that 375° C would be a useful tempering temperature for heat-treated components in this steel. Steel "B" shows a peak in the 0·1 per cent proof stress values between 200° and 300° C and exceeds 120 tons per sq. in in tensile in this range.

The 0·1 per cent proof stress, however, never rises higher than 98·5 tons per sq. in. In order to employ this steel in the region of 120 tons per sq. in the tempering temperature would be substantially lower than for Rex 539, and there is a possibility that the final "locked-up" stress level would be of a high order.

TABLE I.—*Compositions of Ultra-High-Tensile Steels*

	C	Si	Mn	Ni	Cr	Mo	V
American ultra-high-tensile steel "A"	0·25	1·5	1·3	1·8	—	0·5	—
" "B"	0·40	1·9	1·5	—	1·4	0·3	0·25
British Rex 539 steel	0·37	1·58	1·57	1·77	0·11	0·4	0·21
British S.96 steel	0·30	0·23	0·6	2·5	0·65	0·55	—
S.A.E. 4340 (Modified)	0·30	0·30	0·9	1·8	0·75	0·43	0·10

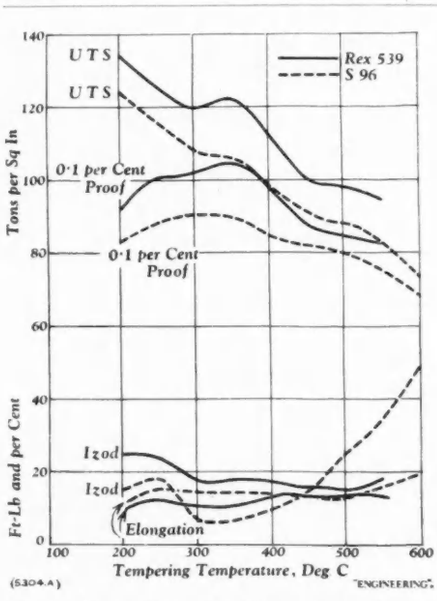


Fig. 1 Comparison of tensile and Izod values of Rex 539 and S 96 series at different tempering temperatures.

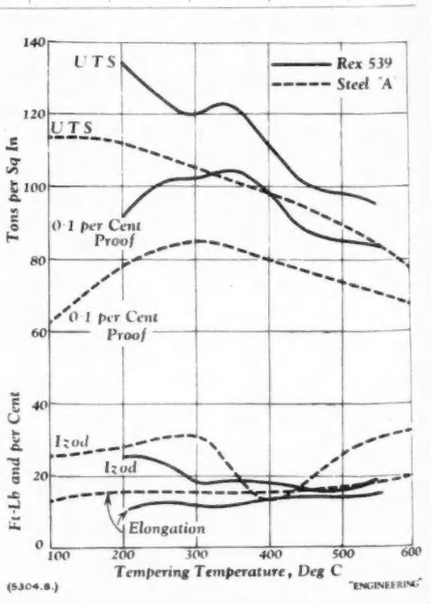


Fig. 2 Comparison of tensile and Izod values of Rex 539 and steel "A" at different tempering temperatures.

Significance of a High Tempering Temperature.—The fact that a proof stress of 100 tons per sq. in and an ultimate stress of 118 tons per sq. in can be obtained with Rex 539 after tempering at as high as 375° C is important from three major aspects: (*a*) the usefulness for applications where high temperatures are encountered, as, for example, in high speed aircraft subject to dynamic heating; (*b*) there is less likelihood of "locked-up" stress remaining in complicated forgings; and (*c*) the steel will be easier to handle from a practical heat-treatment aspect.

Significance of 0·1 per cent Proof Stress/Ultimate Stress Ratio.—It is suggested that if the maximum utilisation of these steels is to be ensured, then the 0·1 per cent proof stress/ultimate stress ratio should lie somewhere in the range 0·75 to 0·90. This should accommodate practical stressing requirements, since full advantage can then be taken of the high 0·1 per cent proof stress value in the initial design of any structure, thereby resulting in a lighter structure of adequate strength. An excessively high 0·1 per cent proof/ultimate stress ratio, however, should be avoided since ductility will be seriously reduced. It is this available ductility which ultimately ensures the safety of the structure by allowing equalisation of stress to take place at stress raisers and other points in the structure where the stress levels cannot be accurately predicted. From the considerations given above, it would seem that the 0·1 per cent proof stress/ultimate stress ratio of these ultra-high-tensile steels is a matter of some considerable consequence. Values are given in Table II.

TABLE II.—*Values of 0·1 per cent Proof Stress/Ultimate Stress Ratios*

Composition "A"	Composition "B"	Rex 539
(80·5/110) 0·73	(88·5/110) 0·80	(96·5/110) 0·87

PREVENTION OF DECARBURISATION BY ELECTROPLATING

Where open type muffle furnaces are employed for heat-treatment and also in the case of salt baths where there may be a tendency to decarburisation, the use of copper plating for stopping-off has been widely employed. It also has definite advantages in ensuring uniform heat-extraction, and appears to prevent "steam blanketing" of the components during quenching. Since the silicon containing steels are known to be rather susceptible to decarburisation, it is essential, unless special atmospheres are used, to employ some form of protection during heat-treatment and tests have been carried out to find the effect of plating on the mechanical properties of Rex 539.

The effect of hydrogen absorbed during plating appears to be persistent in spite of the previously held conception that the hydrogen in steel is more or less completely dissipated by heating. This is apparently true if the steel is heated for long periods below the change point in a vacuum. Rapid heating, in a furnace or salt bath, where the gas atmosphere or the salt film balances the internal pressure, appears to prevent its complete escape. Once the change to gamma iron has taken place, the residual hydrogen appears to be more securely held in solution. The use of copper plating on Rex 539 causes a marked reduction in elongation when the steel is tempered at a temperature below 300° C. The improvement in elongation as the tempering temperature is raised is due, no doubt, to the release of some of the contained hydrogen. These results are shown in Fig. 4.

Since the curves exhibit this marked drop in elongation, it was decided to try the effect of some other form of plating. To this end, nickel-phosphorus plate was chosen, since, being non-electrolytic, there was a chance that the hydrogen absorption would be less. With the nickel-phosphorus plate the effect of hydrogen embrittlement appears to be much reduced and the values of elongation compare favourably with those obtained on the unplated steel treated in a neutral salt bath. In this connection it may be pointed out that the latest American practice is to use a flash of nickel-phosphorus plate and follow this up with copper plate deposited from an acid solution. The nickel-phosphorus coat being amorphous appears to seal the steel against the ingress of hydrogen during the subsequent copper plating.

EXPERIMENTAL COMPONENT MADE FROM BAR STOCK

In order to check the feasibility of producing aircraft components in ultra-high-tensile steel by normal production methods, an axle was made from Rex 539 steel and heat-treated. This axle, shown in Fig. 5, is normally made from S.99 and was reproduced by machining from a 4 in diameter bar of Rex 539. The component was considered to be ideally suited for such a machining and heat-treatment test since it involved a number of changes in section and required a variety of machining processes to produce it. It is known that the Americans have machined components from similar steels in the 120 tons per sq. in condition. Having little experience as yet of machining at such high tensile levels, it was decided that this initial component should be manufactured by the standard shop methods used for the production of high tensile steel components of the order of 80 to 100 tons per sq. in.

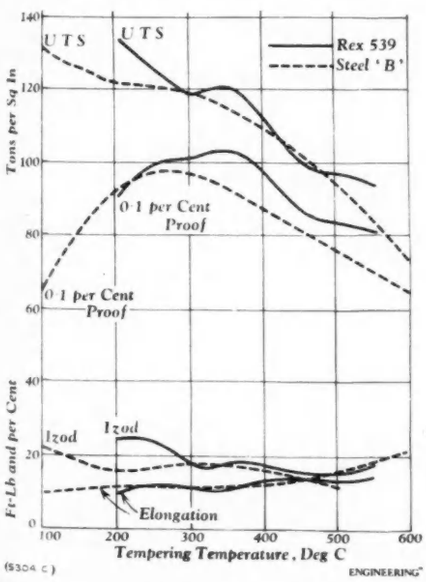


Fig. 3 Tensile and Izod values of Rex 539 and steel "B" at different tempering temperatures.

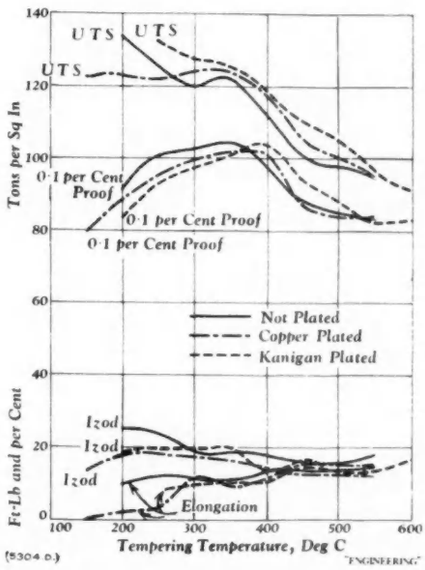


Fig. 4 Effect of plating on mechanical properties of Rex 539 steel.

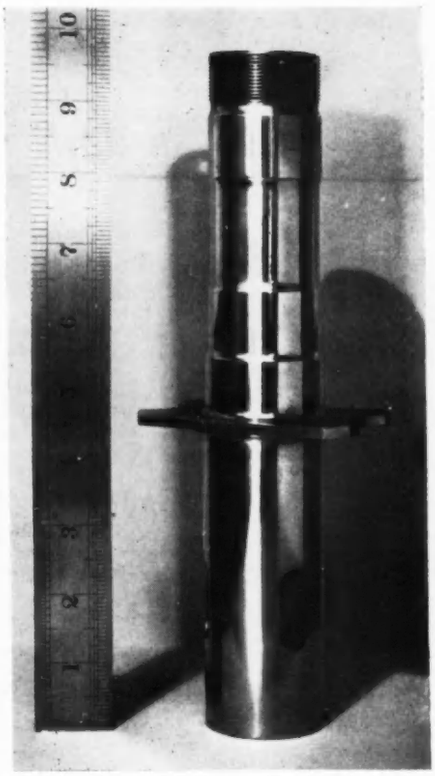


Fig. 5 Aircraft axle made from Rex 539 steel.

Heat-treatment was carried out after all rough machining had been completed and approximately 0·030 in was left on for final grinding. After plating with approximately 0·001 in of copper in a copper cyanide bath, the axle was heat-treated in a neutral salt bath. The part was heated to 860° C and soaked for 20 minutes at this temperature before quenching in oil. It was then tempered at 375° C for 60 minutes and finally quenched in oil. After final grinding, the component showed no evidence of cracks having developed during heat-treatment, quenching or final grinding. The Vickers diamond pyramid hardness was 583. A tensile and Izod test piece, heat-treated at the same time as the axle, gave the figures shown in Table III. It would appear that this material can be handled without any revolutionary changes in machining technique, but care will have to be taken to prevent decarburisation during heat-treatment, and cracking and scorching during grinding.

TABLE III.—*Tensile and Izod Tests on Finished Axle in Rex 539 Steel*

V.P.N.	0·1 per cent proof stress, tons per sq. in	U.T.S., tons per sq. in	Elongation, per cent	Izod, ft. lb
580	100·9	119·6	11·6	23

FORGINGS

Examples of the forgings chosen to be reproduced in Rex 539 are shown in Figs. 6 and 7. They were some of those now in current use for aircraft undercarriage construction and at present made from S99 steel. These forgings, ranging from 65 to 296 lb in weight, were struck from existing dies. A movement, however, is now afoot, headed by Hughes-Johnson Stampings Limited, in association with Light-Metal Forgings Limited, to make use of their light alloy forging experience and produce forgings to dimensions

Continuing Metals and Materials

far closer to the final-machined size. These forgings have been designated "precision forgings." Their advent, together with the 120 tons per sq. in tensile level made possible by the use of these new steels, should herald a distinct advance in the utilisation of steel forgings where a high strength/weight ratio is desired.

Steel forgings for aircraft undercarriage purposes, of the type where a large amount of metal has to be removed to form tubular members, may be from 250 to 500 per cent heavier in the "as forged" than in the "final-machined" size. Precision forging practice should reduce this waste material to as little as 100 to 200 per cent, dependent on the nature of the forging. The hardenability of this steel is such that even in fairly large sections the "as forged" material may be rather harder than is desirable for economic machining by normal machine-shop methods. A double softening treatment is therefore recommended as follows: heat for 2 hours at 720° C and cool in air; heat for 2 hours at 650° C and cool in air. This treatment ensures that the steel is in the 60/70 tons per sq. in tensile range, at which strength it is readily machinable. The normal heat-treatment would of course be carried out ust prior to grinding to final size.

TUBE PRODUCTION

The Chesterfield Tube Company Limited, Chesterfield, have made tubes up to 7 in diameter from Rex 539 and no trouble has been experienced in their fabrication. The larger tubes were hot pierced and hot drawn, the tubes of lesser diameter being extruded. In general, no special treatment was required, the tubes being made by the normal technique employed for high tensile steels. Accles and Pollock, Oldbury, reported that they encountered no serious difficulty in producing steel tubes in the Rex 539 composition down to as thin as 10 s.w.g. Special dies and intermediate anneals appropriate to the steel were used. A tensile strength of 120 tons per sq. in was achieved on heat-treatment.

MECHANICAL PROPERTIES

In seeking after optimum performance for a minimum weight penalty, engineers have exploited to the full the inherent strength/weight characteristics of such materials as D.T.D.683 aluminium alloy. This material which formed the basis of much of the post-war design work in the aircraft field, has a 0·1 per cent proof stress of 27 tons per sq. in and an ultimate of 31 tons per sq. in. The corresponding specific tenacity (U.T.S./S.G.) is of the order of 11.

Using this popular material as a realistic standard against which we may compare the newer steels and the titanium alloys, we find that a steel would have to have an ultimate tensile strength of at least 87·0 tons per sq. in and titanium 50·0 tons per sq. in in order to achieve a comparable specific tenacity. The best available titanium alloys having tensile strengths in the region of 75·0 tons per sq. in would give a specific tenacity of 16·3. However, an ultra high-tensile steel of 120 tons per sq. in tensile strength would have a specific tenacity of 15·25, a figure not far removed from that of the titanium alloys.

From the above and even allowing for the fact that this is a simple comparison based on tensile strength only, it can be seen that the ultra-high-tensile steels may be just as important in the future for engineering design purposes as the established light alloys and the rapidly developing titanium alloys. Table IV gives some further mechanical properties of Rex 539 steel. It is hoped that these attractive properties will promote prototype design in this—a practical ultra-high-tensile steel.

Fig. 6 Forging for aircraft undercarriage in Rex 539. Weight 100 lb.

Fig. 7 Forging for aircraft undercarriage in Rex 539. Weight 68 lb.

Acknowledgments.—The authors wish to thank the directors of Electro-Hydraulics Limited for permission to publish this article and, in particular, to thank Mr. C. B. V. Neilson, technical director, for his help and advice. Also they would like to mention their indebtedness to Thos. Firth and John Brown Limited, Sheffield, for agreeing to make the special cast of Rex 539 steel.

Special acknowledgment must also be made of the help and information supplied by Mr. J. Woolman, director of research, the Brown-Firth Research Laboratories, Sheffield. Thanks are also due to: the Chesterfield Tube Company Limited, Chesterfield; Accles and Pollock Limited, Oldbury, Birmingham; English Steel Corporation Limited, Sheffield; and Hughes-Johnson Stampings Limited, Langley Green, Birmingham, for making available their production facilities and for assistance at all stages of the work.

TABLE IV.—*Mechanical Properties of Rex 539 Ultra-High-Steel (3 in dia)*

Temperature tested at:	Tempered at 300 deg. C		Tempered at 375 deg. C Poisson's ratio 0·289	
	Room	− 78 deg. C	250 deg. C	Room
Limit of proportionality, tons per sq. in	59·8	75·3	36·7	76·0
0·05 per cent proof stress, tons per sq. in	95·3	99·5	63·0	97·5
0·1 per cent proof stress, tons per sq. in	101·5	104·5	72·0	102·5
0·2 per cent proof stress, tons per sq. in	108·0	108·7	83·6	107·2
0·5 per cent proof stress, tons per sq. in	115·5	117·5	88·5	112·0
Maximum stress, tons per sq. in	127·2	126·5	119·5	118·8
Young's Modulus E, tons per sq. in	—	—	—	13,110
Modulus of rigidity, tons per sq. in	—	—	—	5,085
Fatigue (10^7)				
Direct stress, plain, tons per sq. in	±48·0	—	—	—
Basic tensile, plain, tons per sq. in	—	—	—	+69·0
Wöhler fatigue, plain, tons per sq. in	±51·0	—	—	—
Wöhler notched 2·2 fac., tons per sq. in	±27·0	—	—	—
Elongation, per cent	12·0	16·5	21	10
Reduction in area, per cent	39·0	47·0	42·0	34·0
Izod, ft.-lb	17	15	17	18

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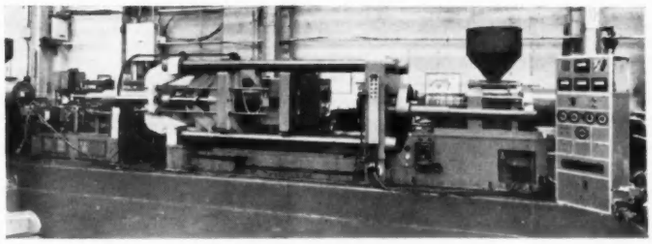
Design

INJECTION MOULDING MACHINE

750 Ton Plant Makes Larger Plastics Components



Developments in thermoplastic materials resulting in increased stiffness have provided greater scope for the designers of plastics mouldings. In particular, larger shapes incorporating thinner sections can now be made in plastics and already there are many new applications including fluorescent lighting fittings, refrigerator and washing machine components, and household articles such as wash baskets, dustbins, watering cans, baby baths, fruit and vegetable containers.

The new developments, however, have increased the technical demands on plastics moulding machines and have resulted in a certain amount of re-thinking on the part of designers of these machines. With the increased size of the mouldings and greater variation in sectional thickness, provision had to be made for larger "shots" and more rapid injection; it also became more difficult to ensure homogeneous mixing and plasticising of the material in the mould; the higher injection pressures and mould locking pressures, the need for greater clearances to accommodate the larger moulds, for a reduction in the time cycle of operations and to incorporate automatic control of these operations, had all to be taken account of in any new design of machine.

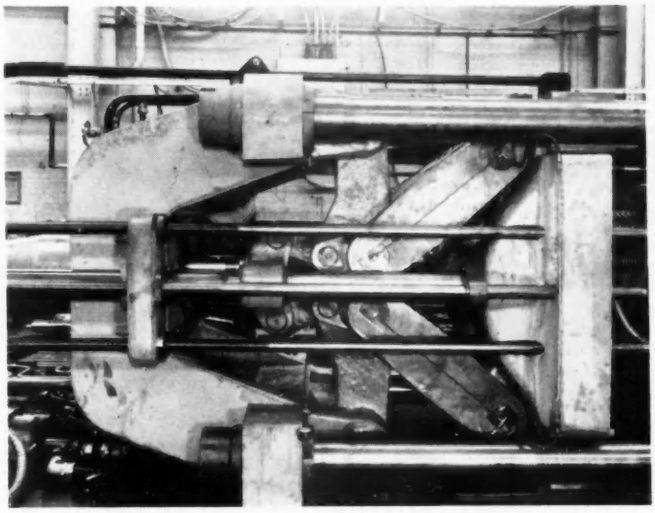


Fig. 1 (above) The new plastics injection moulding machine incorporates an in-line preplasticiser unit and a "Thermax" heating chamber. A mould locking force of 750 tons can be applied and injection shots of polystyrene up to 60 oz or 100 cu. in can be made.

Fig. 2 (left) The four point toggle mechanism, shown here in the "open" position, is operated by a hydraulic power unit which moves and secures the heavy platens. The toggle pins operate in hardened and ground sleeves.

The new injection moulding machine—type 60MP60 (Fig. 1), which has been designed and built by the Projectile and Engineering Company, London, S.W.8, is an example of how the new requirements can be met. The new machine—of which there are six on order for the home market or for export—incorporates an in-line Peco preplasticiser unit, a design feature which has proved to be particularly advantageous when large "shots" are required. For example, the application of this principle to 54 oz high impact polystyrene mouldings with a mean wall thickness of 0·110 in resulted in an improvement in cycle times of 35 per cent. In addition, the incorporation of a "Thermax" heating chamber has considerably improved the efficiency of the plasticising unit, reducing the cycle times still further and providing a more homogeneous mixing of the plastics material.

The machine is designed for mould materials requiring a wide range of pressures, for in addition to providing the normal injection pressure variation which was a feature of the company's earlier smaller machines, there is complete interchangeability of injection chambers so that 60 oz mouldings in polystyrene or 83 oz mouldings in polythene, as well as small 4 oz shots with no material loss, can be handled.

An interesting feature of the design is the smooth action of the hydraulic operated four-point toggle closing mechanism (Fig. 2), which provides the 750 ton locking force to the large, 54 in by 56 in, platens. The weight of the moving platens is taken by bearing shoes that are mounted on hard chrome slides fixed to the base of the machine. An even distribution of load and pressure on the moving back platen is obtained by a large diameter central mould height adjusting screw with buttress-form threads. Four high-tensile steel tie-bars guide this platen, and the top two bars can be easily withdrawn to enable the large dies to be mounted. An electric motor provides power to operate the adjusting screw, controlling mould height between 19 in and 36 in; manual operation is also possible in case of emergency. The smooth, balanced movement of the toggle linkage ensures a quick release of the heavy moulds.

When the pressures, temperatures and cycle times have been adjusted to give the desired quality of moulding, production is automatically controlled by push buttons on the machine, while the electrical instruments are housed in a separate cabinet for ease of access and maintenance.

SAFER AIRCRAFT LANDINGS

Coloured Bars to Prevent Undershooting

With the object of preventing aircraft accidents due to undershooting on landing, operational tests are in progress on a "visual glide path indicator." The Ministry of Transport and Civil Aviation have installed the first indicator at Blackbushe Airport, where it has been in operation since 14 July. Similar installations are being made at Aberdeen, Prestwick, Belfast and Liverpool.

In about a quarter of the accidents which occur at landing, the subsequent investigation has failed to show any defect in the aircraft or its equipment. Recent research at the Royal Aircraft Establishment, Farnborough, has shown that in many of the weather conditions in which transport aircraft now fly, the height guidance which the pilot derives from looking at the ground is poor, particularly in rain and low cloud, when he may see only a portion of the runway. The result is that in a certain proportion of landings, the aircraft touches down short of the runway, and in some of these "undershoots" there is a serious accident. It is hoped that the visual glide path indicator will prevent over 80 per cent of such incidents.

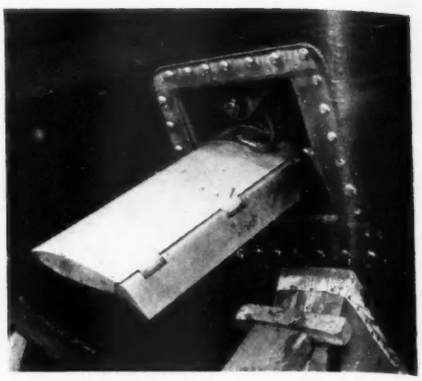
The indicator, which is very simple, consists of two bars, about 30 ft wide, arranged transverse to the runway at the fore and aft limits of the desired touchdown area. Besides marking this area, the bars tell the pilot when he is approaching the runway along a path which is between certain safe limits, and incidentally provide roll guidance just before touch. If the aircraft is too low, both bars are red, and if the pilot continues to fly "in the double red," he will touch down short of the runway. If the aircraft is too high, both bars are white, and if he continues to fly "in the double white" he will touch down too far along the runway, and perhaps run off the far end. If the aircraft is within the desired limits, the pilot sees the furthermost bar red, and the nearer bar white, and if he continues to see this signal the aircraft will touch down in the desired landing area. The indicator is easy to use because, as the aircraft approaches the runway, the vertical width of the pathway never gets so narrow that the pilot cannot keep the aircraft between the limits. This is the first device which gives visual height guidance in an easily usable form right down to touchdown.

Another advantage of the indicator is that it is bright enough to be used in daytime. This is important, because, although the landing accident rate in daytime is only about one-third of what it is at night, about five times as many landings are made in daytime. The reliability is also very high, firstly, because there are a large number of lamps, and secondly, because there are no lenses in the optical system on which condensation can occur. In the three-colour indicators previously used, this condensation caused the three colours to mix, thereby producing a "fly down" indication even when the aircraft was low. Nothing of this kind can occur in the new indicator.

Continuing **Design**

STABILISED MINESWEEPER

HMS Reedham, launched on 19 August, is the first Royal Navy vessel to be fitted with the Denny-Brown/Saunders-Roe small ship stabilisers. A minesweeper, the vessel is 106 ft long and is entirely of wood; it is intended for operation in coastal waters. She has two of the stabilising fins (one is shown in the illustration), which are fully retractable by hydraulic power. In use their movement is controlled by a Muirhead gyro unit. The reduction in roll of a warship has many obvious advantages apart from the added comfort to personnel. Her speed in rough weather can be materially increased and her armament is rendered more effective. Risk of injury to the crew is also reduced.



HMS Reedham is the first minesweeper of the Royal Navy to be fitted with stabilisers.

UNDER-SEA CABLES TO SWEDEN AND SAN JUAN

Contracts have recently been placed with British manufacturers for a new submarine cable system between the United Kingdom and Sweden costing about £1½ million. The new cable, which will be about 530 nautical miles long, will have a capacity of 60 telephone circuits and will provide relief on the Anglo-Dutch cables over which most of the United Kingdom-Swedish telephone traffic at present passes. At the same time it will provide a direct and more economic routing for the growing volume of telephone and telex traffic between the United Kingdom and Sweden, and via Sweden to Finland. The system is due for completion in October, 1960.

The terminals of the submarine cable system will be at Goteborg and Middlesborough and 12-circuit groups will be extended, without demodulation to audio frequency, to Stockholm and London. This will provide circuits about 1,100 miles long between the capital cities. Conventional methods of signalling will be employed on the circuits and four-wire switching facilities will be installed in London so that the circuits can be extended to Europe or North America without additional overall attenuation.

The submarine cable will use some 28 of the new long-distance submerged repeaters which were designed for use with 0·99 in diameter lightweight Polythene dielectric coaxial cable, which is only suitable for use in very deep water. As a result it has been necessary to develop a new type of shallow-water cable which differs from conventional 0·62 in diameter cable. The centre conductor is a core of mild-steel strands over which is placed a copper tape, instead of being of solid copper.

The submarine cable will be extended to the terminal stations at each end by about 9 miles of land cable. This will be of similar construction to the submarine cable except that it will have soft iron tapes added as a screen against electrical interference.

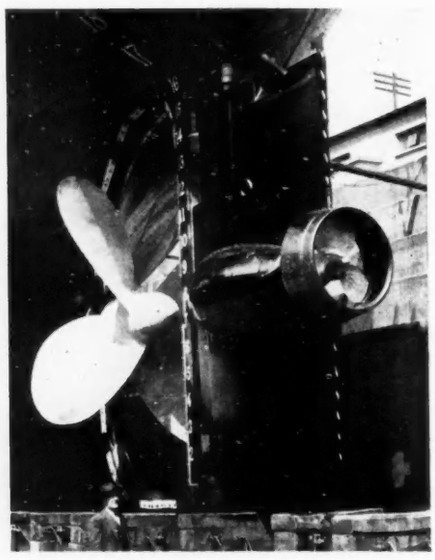
The new repeaters, which will be spliced into the cable about every 18 nautical miles along its length and which will amplify signals in both directions, differ in a number of respects from those used on the Newfoundland-Nova Scotia section of the transatlantic telephone cable system. In particular, a new type of valve will be employed which will reduce the voltage per repeater from 123 to 75 volts, thus reducing very considerably the power feeding voltage required for the system. Also the repeaters will incorporate a supervisory system which will enable measurements of loop gain, noise and intermodulation products to be made to each repeater without taking the system out of commission. Power feeding and control of the supervisory system will be from the Middlesbrough station.

HMTS Monarch will be used to lay the cable and repeaters.

The contractors concerned are Standard Telephones and Cables Limited for the repeaters, submarine cable and the repeater supervisory and terminal equipment; Telegraph Construction and Maintenance Company Limited for the land cable and Westinghouse Brake and Signal Company for the submerged repeater power feeding equipment.

Another submarine cable contract obtained by Standard Telephones and Cables Limited, valued at 2½ million dol, has been placed by the American Telephone and Telegraph Company, New York. It calls for the supply of over 700 nautical miles of deep-sea type coaxial telephone cable which will form part of a new 36-channel system to be installed next year between Miami and San Juan.

ACTIVATED RUDDERS FOR PULP-CARRYING SHIPS



A Pleuger Aktiv rudder being fitted on the Elizabeth Bowater, to increase manoeuvrablity in confined waters.

To provide greater manoeuvring ability in confined waters and at dock entrances, Pleuger Aktiv rudders have been fitted to the pulp-carrying ships Elizabeth Bowater and Constance Bowater, which are the first two vessels to be built for the Bowater Steamship Company Limited by the Caledon Shipbuilding and Engineering Company Limited, Dundee. In the activated rudder, an electric motor with propeller is mounted as an integral part of the rudder, so that, when driving, the propeller is able to exert steering torque on the vessel even when she has developed little or no way. A general view of such a propeller, in the course of being fitted to the Elizabeth Bowater is shown in the accompanying illustration.

The rudder motor is rated at 150 h.p. and is required for direct-on-line starting, and under this condition, takes three times full load current. To drive the rudder motor, a motor-alternator set was supplied by Crompton Parkinson Limited, Crompton House, Aldwych, London, W.C.2. The company, in fact, supplied all the ancillery equipment in the Elizabeth Bowater. The set comprises a light compound-wound 220 V d.c. motor directly coupled to a three-phase 50 cycle 380 V alternator—both machines being mounted on a common bedplate. The alternator has an output of 142½ kW, 190 kVA at 0·75 p.f., at full load speed of 1,500 r.p.m. Although the inherent voltage regulation of the machine is good, an Isenthal voltage regulator has been supplied with the first equipment which gives regulation to plus and minus 2½ per cent from full load to no load. Later vessels will have Crompton Parkinson self-regulating alternators of the Magnicon type, which have an inherent voltage regulation of plus and minus 2½ per cent. The machines supplied comply with Lloyds' requirements for machines for use in ocean-going vessels operating in tropical waters.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

LONDON
"Silicones for the Electrical Engineer," by B. F. W. Hayward. West London Branch. 134 King Street, Hammersmith, W.6. Tues., 7 Oct., 7.30 p.m.
"Modern Development in Cold Cathode Lighting," by E. A. Langsdon. South West London Branch. Prince of Wales Hotel, opposite Wimbledon Railway Station, S.W.19. Thurs., 9 Oct., 7.45 p.m.
BRADFORD
"Electrode Boilers and Their Applications," by J. C. Edwards. Bradford Branch. Midland Hotel, Bradford. Wed., 8 Oct., 7.30 p.m.

British Institution of Radio Engineers

NEWCASTLE UPON TYNE
"Electronic Control Systems for Large Astronomical Telescopes," by G. H. Hickling and I. Paul. North Eastern Section. Neville Hall, Westgate Road, Newcastle upon Tyne. Wed., 8 Oct., 6 p.m.
WOLVERHAMPTON
"An Introduction to Colour Television," by T. Jacobs. West Midlands Section. Wolverhampton and Staffordshire College of Technology, Wulfruna Street, Wolverhampton. Wed., 8 Oct., 7.15 p.m.

Diesel Engineers and Users Association

LONDON
Annual General Meeting. "Automatic Control of Engine Driven Plants," by E. R. Hill. Institute of Marine Engineers, 76 Mark Lane, E.C.3. Thurs., 16 Oct., 2 p.m.

Illuminating Engineering Society

LONDON
Presidential Address on "Light and Life," by C. C. Smith. Royal Institution, 21 Albemarle Street, W.1. Tues., 14 Oct., 6 p.m.
HULL
"Lighting for Sport," by M. W. Pierce. Leeds Centre. Offices of the Yorkshire Electricity Board, Ferensway, Hull. Mon., 6 Oct., 6.30 p.m.
SHEFFIELD
Chairman's Address by K. Marshall. Sheffield Centre. Grand Hotel, Sheffield. Mon., 13 Oct., 6.30 p.m.

Incorporated Plant Engineers

LONDON
"The Free Piston Engine and Its Applications," by R. W. S. Michell. London Branch. Royal Society of Arts, John Adam Street, Adelphi, W.C.2. Tues., 7 Oct., 7 p.m.*
EDINBURGH
"District Heating," by G. E. H. Lewis. Edinburgh Branch. 25 Charlotte Square, Edinburgh. Tues., 7 Oct., 7 p.m.
GLASGOW
"Corrosion," by F. S. Bricknell. Glasgow Branch. Scottish Building Centre, 425 Sauchiehall Street, Glasgow. Thurs., 9 Oct., 7.15 p.m.
NEWCASTLE UPON TYNE
"Factory Inspection," by C. R. Noble. North East Branch. Roadway House, Oxford Street, Newcastle upon Tyne. Thurs., 9 Oct., 7 p.m.
NOTTINGHAM
"Field Work in Atmospheric Pollution," by D. G. Lucas. East Midlands Branch. County Hotel, Theatre Square, Nottingham. Wed., 8 Oct., 7 p.m.
PETERBOROUGH
Discussion on "The Jodrell Bank Radio Telescope." Peterborough Branch. White Lion Hotel, Church Street, Peterborough. Tues., 7 Oct., 7.30 p.m.

Institute of Marine Engineers

LONDON
Presidential Address on "The Training of Sea-Going Engineers: A Brief Historical Survey," by E. L. Denny. Tues., 7 Oct., 5.30 p.m.*
"Gas Turbines," by D. L. Brown. Junior Lecture. Poplar Technical College, E.14. Thurs., 9 Oct., 6.30 p.m.
BIRMINGHAM
Film: "Petroleum and Associated Industries." West Midlands Section. Birmingham and Midland Institute, Paradise Street, Birmingham. Wed., 8 Oct., 7 p.m.
GLASGOW
"The Ship," by J. Robson. Scottish Section. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank Crescent, Glasgow, C.2. Wed., 8 Oct., 7.30 p.m.
NEWCASTLE UPON TYNE
"Developments and Possibilities of the Doxford Marine Engine," by P. Jackson. North East Coast Section. Stephenson Building, King's College, Claremont Road, Newcastle upon Tyne. Thurs., 9 Oct., 6.15 p.m.*

Institute of Road Transport Engineers

BEDFORD
"Trends in Modern Road Passenger Transport," by R. Cox. Eastern Centre. Swan Hotel, Bedford. Tues., 7 Oct., 7 p.m.
BRISTOL
Discussion on "Road Transport Law." Western Centre. Royal Hotel, Bristol. Tues., 7 Oct., 6.30 p.m.
CARDIFF
"Development of Automatic Transmission for Commercial Vehicles," by R. B. Robinson. South Wales Centre. South Wales Institute of Engineers, Park Place, Cardiff. Fri., 10 Oct., 7 p.m.
HOVE
"Trends in Modern Road Passenger Transport," by R. Cox. Southern Centre. Palmeira Hotel, Hove. Wed., 8 Oct., 7.30 p.m.
NOTTINGHAM
"Development of Automatic Transmission for Commercial Vehicles," R. B. Robinson. East Midlands Centre. Mechanics' Institute, Nottingham. Wed., 8 Oct., 7.30 p.m.

Institution of Chemical Engineers

MANCHESTER
"Mass Transfer and Diffusion Phenomena in a Rotary Concentric-Cylinder Distillation Column," by N. Macleod. North Western Branch. Manchester College of Science and Technology, Jackson Street, Manchester. Tues., 14 Oct., 6.30 p.m.

Institution of Civil Engineers

LONDON
"Engineering Problems in Recent River Valley Projects in India," by K. L. Rao. Tues., 7 Oct., 5.30 p.m.*

Institution of Electrical Engineers

LONDON
Inaugural Address by the President, S. E. Goodall. Thurs., 9 Oct., 5.30 p.m.*
BIRMINGHAM
Annual General Meeting and Conversazione. Chairman's Address, by J. Ashmore. South Midland Centre. Grand Hotel, Birmingham. Tues., 7 Oct., 6 p.m. (Tickets required.)
EDINBURGH
Chairman's Address, by R. J. Rennie. South East Scotland Sub-Centre. Carlton Hotel, North Bridge, Edinburgh. Tues., 7 Oct., 7 p.m.
LEEDS
Chairman's Address, by J. D. Nicholson. North Midland Centre. Offices of the Yorkshire Electricity Board, Leeds. Tues., 7 Oct., 6.30 p.m.
LIVERPOOL
Chairman's Address, by J. Collins. Mersey and North Wales Centre. Royal Institution, Colquitt Street, Liverpool. Mon., 6 Oct., 6.30 p.m.
LOUGHBOROUGH
Annual General Meeting. Chairman's Address, by D. E. Lambert. East Midland Centre. Loughborough College, Loughborough. Tues., 7 Oct., 6.30 p.m.*
MANCHESTER
Chairman's Address, by Professor F. C. Williams. North Western Centre. Engineers' Club, Albert Square, Manchester. Tues., 7 Oct., 6.30 p.m.

Institution of Engineering Designers

NEWCASTLE UPON TYNE
"Design of Water Turbine Driven Alternating Current Generators," by G. R. Small. North East Branch. Northern Architectural Association's hall, 6 Higham Place, Newcastle upon Tyne. Mon., 13 Oct., 7.15 p.m.

Institution of Engineers-in-Charge

LONDON
Annual General Meeting. Caxton Hall, off Victoria Street, S.W.1. Wed., 8 Oct., 6.30 p.m.

Institution of Engineers and Shipbuilders in Scotland

GLASGOW
Presidential Address, by Professor J. Small. Tues., 7 Oct., 6.30 p.m.

Institution of Heating and Ventilating Engineers

LONDON
"Waste Heat Recovery from Diesel Engines," by R. M. Tufnell. Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, S.W.1. Wed., 8 Oct., 6 p.m.*
BRISTOL
"Survey of Methods of Pressurisation for Medium and High Pressure Hot Water Systems," by J. R. Kell. South Western Branch. R.W.A. School of Architecture, Bristol. Tues., 7 Oct., 6.30 p.m.
NEWCASTLE UPON TYNE
"Applications of Structural Plastics in Heating and Ventilating," by R. W. Marks. North East Coast Branch. Institute of Mining and Mechanical Engineers, Neville Hall, Westgate Road, Newcastle upon Tyne. Tues., 7 Oct., 6.30 p.m.

Institution of Locomotive Engineers

LONDON
"The Mechanics of the Train in the Service of Railway Operation," by S. O. Ell. Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, S.W.1. Wed., 15 Oct., 5.30 p.m.*

Institution of Mechanical Engineers

LONDON
Annual General Meeting and Chairman's Address. Automobile Division. Tues., 7 Oct., 6 p.m.*
BLACKBURN
Discussion on "Atomic Energy." North Western Branch. Offices of the North Western Electricity Board, Jubilee Street, Blackburn. Wed., 8 Oct., 7 p.m.
LEICESTER
"Mechanical Properties of Plastics," by Dr. E. R. Howells. East Midlands Branch. College of Technology and Commerce, Leicester. Wed., 8 Oct., 7.15 p.m.
MIDDLESBROUGH
"Packed Glands for High Pressures: An Analysis of Fundamentals," by Professor J. L. Thompson. North Eastern Branch. Cleveland Scientific and Technical Institute, Corporation Road, Middlesbrough. Tues., 7 Oct., 6.15 p.m.
NEWCASTLE UPON TYNE
Chairman's Address by Sir William Scott. North Eastern Branch. Neville Hall, Westgate Road, Newcastle upon Tyne. Mon., 6 Oct., 6 p.m.
RUGBY
"The Design and Development of Lightweight Marine Gas Turbines for Electric Generator Drive," by A. W. Pope. Eastern Branch. College of Technology and Arts, Rugby. Tues., 7 Oct., 6.30 p.m.

Institution of Production Engineers

EDINBURGH
"The Mechanical Engineering Research Laboratory: Work of the Mechanisms, Engineering Metrology and Noise Control Division," by Dr. C. Timms. Edinburgh Section. North British Hotel, Princes Street, Edinburgh. Wed., 15 Oct., 7.30 p.m.
LIVERPOOL
"The 1960 Associate Membership Examination and Its Implications," by F. W. Cooper. Liverpool Section. Exchange Hotel, Tithebarn Street, Liverpool 2. Wed., 8 Oct., 7.30 p.m.

Institution of Public Health Engineers

LONDON
"Extremes of Rainfall," by A. Bleasdale. Caxton Hall, off Victoria Street, S.W.1. Thurs., 16 Oct., 6 p.m.

Institution of Structural Engineers

LONDON
"Design of Cities," by Johnson Marshall. London Graduates' and Students' Section. Tues., 14 Oct., 6.30 p.m.
BRISTOL
Chairman's Address on "Modular Co-ordination in Building," by Peter Gardiner. Western Counties Branch. Engineering Laboratories, The University, Bristol. Fri., 17 Oct., 6 p.m.
GLASGOW
Chairman's Address, by W. Heigh. Scottish Branch. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank Crescent, Glasgow, C.2. Mon., 13 Oct., 7 p.m.

Junior Institution of Engineers

LONDON
"Photography in Industry," by C. Newland. Fri., 10 Oct., 7 p.m.*

Liverpool Engineering Society

LIVERPOOL
Presidential Address. Wed., 8 Oct., 6 p.m.

Liverpool Metallurgical Society

LIVERPOOL
Presidential Address on "Alternative Methods of Iron and Steel Production," by Dr. C. Bodsworth. Department of Metallurgy, The University, 146 Brownlow Hill, Liverpool 3. Thurs., 9 Oct., 7 p.m.

Newcomen Society

LONDON
Annual General Meeting. "A Neglected Genius of Seventeenth Century Technology," by L. E. Harris. Wed., 8 Oct., 5.30 p.m.

Physical Society

LONDON
"Vibration: Its Causes, Measurement and Reduction," by Dr. A. J. King, Acoustics Group. Physics Department, Imperial College, South Kensington, S.W.7. Fri., 10 Oct., 5.30 p.m.*

Royal Statistical Society

LONDON
"Measuring Industrial Concentration," by R. W. Evely. Study Section. Royal Institute of Public Health and Hygiene, 28 Portland Place, W.1. Wed., 8 Oct., 6.15 p.m.*
LIVERPOOL
"Operational Research in Industry," by Dr. K. D. Tocher. Merseyside Industrial Applications Group. Royal Institution, Colquitt Street, Liverpool. Tues., 14 Oct., 7 p.m.*

Society of Engineers

LONDON
"Bridge Over the River Kwai," by K. H. Best. Geological Society, Burlington House, Piccadilly, W.1. Mon., 6 Oct., 5.30 p.m.*

Society of Instrument Technology

LONDON
"Aircraft Flight Simulators," by Dr. A. E. Cutler. Control Section. Manson House, Portland Place, W.1. Thurs., 9 Oct., 6 p.m.*
BIRMINGHAM
"Instrumentation in the Oil Industry," by A. Cowan. Midland Section. Regent House, St. Phillips Place, Colmore Row, Birmingham 3. Fri., 10 Oct., 7 p.m.
SHEFFIELD
"The Education and Training of Instrument Personnel," by E. B. Jones. South Yorkshire Section. The University, St. George's Square, Sheffield 1. Mon., 6 Oct., 7 p.m.

West of Scotland Iron and Steel Institute

GLASGOW
Presidential Address, by Dr. H. Harris. Fri., 17 Oct., 6.45 p.m.

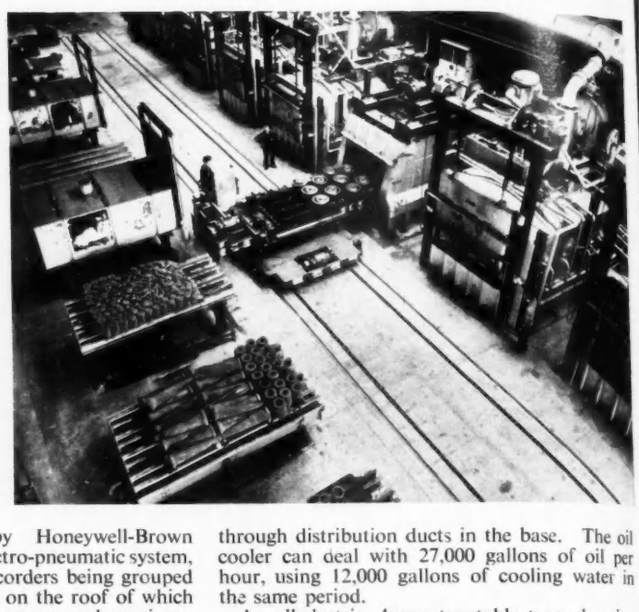
The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than three weeks before the date of the meeting.

* An asterisk is placed where it is understood that refreshments are available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury Square, London, W.C.1. (LANgham 5927.)
British Institution of Radio Engineers, 9 Bedford Square, London, W.C.1. (MUSeum 1901.)
Diesel Engineers and Users Association, 19 Old Queen Street, London, S.W.1. (TRAfalgar 5597.)
Illuminating Engineering Society, 32 Victoria Street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 2 Grosvenor Gardens, Westminster, London, S.W.1. (SLOane 0469.)
Institute of Marine Engineers, Memorial Building, 76 Mark Lane, London, E.C.3. (ROYal 8493.)
Institute of Road Transport Engineers, 69 Victoria Street, London, S.W.1. (ABBey 6248.)
Institution of Chemical Engineers, 16 Belgrave Square, London, S.W.1. (BELgravia 3647.)
Institution of Civil Engineers, Great George Street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineering Designers, 38 Portland Place, London, W.1. (LANgham 8847.)
Institution of Engineers-in-Charge, 13 Grange Close, Edgware, Middlesex. (MILl Hill 3543.)
Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank Crescent, Glasgow, C.2. (Central 5181.)
Institution of Heating and Ventilating Engineers, 49 Cadogan Square, London, S.W.1. (SLOane 3158.)
Institution of Locomotive Engineers, 28 Victoria Street, London, S.W.1. (ABBey 6672.)
Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Production Engineers, 10 Chesterfield Street, London, W.1. (GROsvenor 5254.)
Institution of Public Health Engineers, 118 Victoria Street, London, S.W.1. (VICtoria 3017.)
Institution of Structural Engineers, 11 Upper Belgrave Street, London, S.W.1. (SLOane 7128.)
Junior Institution of Engineers, Pepys House, 14 Rochester Row, London, S.W.1. (VICtoria 0786.)
Liverpool Engineering Society, 9 The Temple, 24 Dale Street, Liverpool 2. (Central 3717.)
Liverpool Metallurgical Society, Greenhithe, Grosvenor Road, St. Helens, Lancs. (St. Helens 5879.)
Newcomen Society, Science Museum, Exhibition Road, London, S.W.7. (KENsington 1793.)
Physical Society, 1 Lowther Gardens, South Kensington, London, S.W.7. (KENsington 0048.)
Royal Statistical Society, 21 Bentinck Street, London, W.1. (WELbeck 7638.)
Society of Engineers, 17 Victoria Street, London, S.W.1. (ABBey 7244.)
Society of Instrument Technology, 20 Queen Anne Street, London, W.1. (LANgham 4251.)
West of Scotland Iron and Steel Institute, 39 Elmbank Crescent, Glasgow, C.2. (Central 5181.)

Production

CENTRAL HEAT TREATMENT FOR TWO WORKS



Centralising all the company's heat treatment, the new Firth-Derihon shop can deal with forgings from a few ounces to 800 lb each.

Firth-Derihon Stampings Limited, Tinsley, Sheffield, 9, opened works at Darley Dale, Matlock, Derbyshire, in 1941–42, and to meet the conditions at the time, installed there coke-fired gas producers for firing the forge reheating and heat treatment furnaces. In 1956, it was decided to modernise the heat treatment department, and to increase its capacity to deal with the output from the Tinsley works as well as Darley Dale. Town gas firing was chosen in view of the increasing maintenance on the producer gas plant, and the need for much greater accuracy of heat treatment of high quality alloy and carbon steels, nickel-based and titanium alloys.

A new 15 in diameter high-pressure gas main, 12 miles long, brings the gas from Chesterfield, and a new meter and governor house at Darley Dale connects it to the modified internal gas main. There are three heat treatment furnaces and two for tempering, an oil quenching machine and a turntable charging machine, all supplied by Gibbons Brothers Limited, Dudley. Loading and cooling tables, an instrument and control room and a waste gas discharge system complete the installation.

All the furnaces are 11 ft long, 6 ft 6 in wide and 3 ft 3 in high to the spring of the door arch. They take loads up to 5 tons in weight. The heat treatment furnaces have operating temperature ranges of 200° C to 750° C with forced re-circulation and 750° C to 1,250° C without. Normal operating temperatures for the tempering furnaces are 200° C to 750° C with forced re-circulation. Furnace temperatures are electrically controlled by Honeywell-Brown instruments through an electro-pneumatic system, all the instruments and recorders being grouped in a central control room, on the roof of which are the duplex air compressors and receivers. Gas flow and total gas consumption of each furnace are recorded by Kent instruments. Waste gases from the furnaces are collected by an overhead main and discharged to atmosphere by way of an exhaust fan and chimney stack.

The oil quenching machine is of the fully enclosed type, with automatic door operation and automatic lifting and lowering of the load during quenching, with variable oscillation. Oil is drawn from the machine for cooling in a water cooled heat exchanger, and returned to the tank through distribution ducts in the base. The oil cooler can deal with 27,000 gallons of oil per hour, using 12,000 gallons of cooling water in the same period.

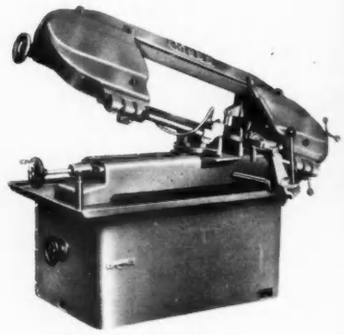
An all-electric, 4-arm turntable type charging machine runs between the lines of furnaces and loading and cooling tables, and handles loads up to five tons made up of a wide range of forgings from a few ounces to about 800 lb each in weight. All material is received at the works on stillages, and forklift trucks are used for internal transport. Electric overhead cranes are used in the main heat treatment bay for assembling the loads of heavier forgings on the loading tables. Once assembled, a load goes through all operations in the works as a unit.

MAKING THE BEST USE OF SPACE

Sometimes it seems impossible to apply the logical solution to a problem because a single factor stands in the way. Such a position arose at the Edmonton, London, N.18, works of British Oxygen Gases Limited (Equipment Division), when it was required to store welding rods in one ton unit loads on 3 ft square pallets. Some 400 tons of material were involved. The building available has a ceiling 12 ft 6 in high, supported by a number of large pillars at intervals of 15 ft 3 in, and all attempts to design racking of the normal straight type led to a low standard of space utilisation. Either the bay widths were dependent upon the pitch of the pillars, or the pillars obstructed the gangways and hindered the use of trucks.

The logical bay width for 3 ft pallets was about 3 ft 7 in, and the diagonal distance across each bay proved to be nearly one third of the distance between pillars. By rounding up the dimensions of the bays to coincide exactly with the pitch of the pillars it proved possible to provide a neat workable layout, and at the same time to conceal the pillars within the structure of the racks without sacrificing storage area. Racks have been built in diamond formation from Dexion slotted angle, and a simple layout, suitable for fork-lift trucks, is the result.

Orthodox layouts of straight racking would have led to poor space utilisation in this British Oxygen stores. Diamond formation made better use of space without modifying the building.



Simplicity and heavy duty are characteristics of the Meda horizontal bandsaw.

HORIZONTAL BANDSAW

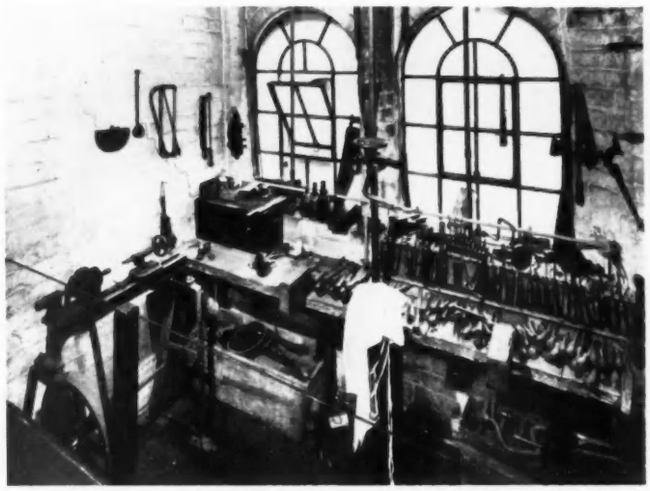
By arrangement with Meba Maschinenbau Esslingen, Germany, the Startrite Machine Tool Company Limited, Bishops House, Gads Hill, Gillingham, Kent, are distributing the Meba horizontal bandsawing machine in the UK.

As will be seen from the illustration above, the machine has a pivoted saw frame and drive which allows the saw to cut any stock placed in the vice. A cut of only 0·042 in wide is made by the saw, which can be run at any speed from 46 to 230 ft per min with infinitely variable control, to cut any material from steel to plastics. Infinitely variable hydraulic control of feed prevents excessive blade pressures and breakages. A single lever controls the adjustable end stop and the clamping vice, which can be set for cutting at any angle from 45° to 90°. Two models of machine are available, with bar cutting capacities of 10 in or 12¾ in diameter.

CRAFT WORKSHOPS DISPLAYED

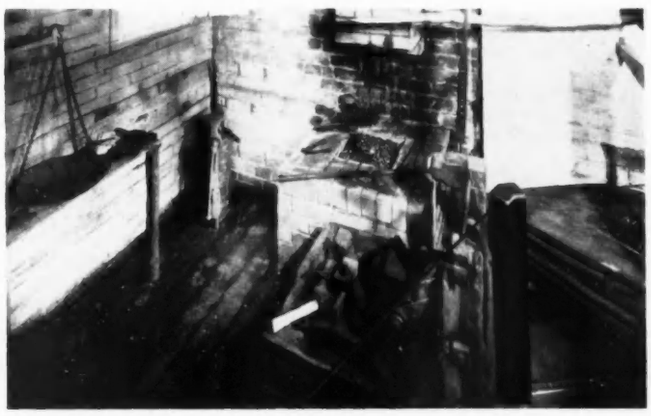
British industry was founded on craftsmanship, and this remains to-day, in spite of many changes, the basis of the country's production methods. Modern techniques give to machines the hot, heavy, dirty work which past generations had to do by hand, and the automatic factory can produce goods faster, cheaper and in greater abundance than a host of craftsmen could do. But somebody has to build the automatic factory, and in this work the craftsman still plays his part. Perhaps there will be fewer craftsmen needed in the future; certainly, as far as can be foreseen, there will always be a need for some, and the indications are that they will have to be even more highly skilled than in the past.

This country has no cause to be ashamed of her craftsmen of bygone days; quite the reverse, in fact, and a lot can be learnt from them. The difficulty has been, until recently, that there were very few facilities, with the notable exception of those provided by York Museum, for studying old crafts without spending a lot of time on the subject, which only an enthusiastic student was likely to do. Old crafts died out, their equipment was dispersed, and they were forgotten, except in the private archives of a few interested parties.



Gunmaking, a celebrated Birmingham trade, is represented by this action-filer's shop.

A "five-pin board", or bench for five workers, is typical of the jewellery trade.



Only the poorest of equipment was used by the nailers. The glass screen of the new display technique can be seen in the foreground.

A valuable step forward has now been taken by the Birmingham Museum of Science and Industry, Newhall Street, Birmingham, 3, where seven craftsmen's workshops, reconstructed exactly as they were when in use, are now on view to the public. Two of these shops, a silversmith's and a brass founder's, were completed some time ago; the remaining five have just been brought into display. They comprise a gunmaker's, a brass turner's, a nailer's, a jeweller's and a cooper's. All the trades represented had strong Birmingham and Midlands connections and the last, coopering, though not peculiar to the area, was widely practised there by the small "one-man" type of business.

In setting out the display, every effort has been made to present workshops which look, not only as if they could be used, but as if, in fact, they were in regular operation. The overall thrown across the bench or hung on a nail on the back of the door, the teapot, cup and half-empty milk bottle, the cigarette packet, are all justifiable little display tricks which, added to the swarf or shavings on the floor, and the partly-finished work lying about, help to give a feeling of authenticity, a sense of being "lived in," to the displays. There is, indeed, much more that is truly authentic than can ever be realised by the visitor; the dust and scale which lie on the nailmaker's workstand or "block," for example, are genuine. They were brought, with the tools and equipment, from the original workshop.

A certain amount of licence has had to be taken with some of the exhibits, however, because of the practical impossibility of displaying everything exactly as it used to be. The gunmaker's shop, shown in the illustration on this page, is really a composite collection, though it exemplifies the trend in the trade during recent years. In its heyday, Birmingham gunmaking was probably one of the most remarkably subdivided trades that ever existed, each production operation being performed not only by an individual craftsman, but often by a separate firm, many of the craftsmen being self-employed. Up to about the middle of last century, the production of a gun was distributed among perhaps 50 individuals, and a representation of the trade at its greatest manual-labour period could involve the display of a large number of workshops. More recently, the tendency has been for more operations to be carried out in a single workshop, especially in relation to repair work. In its essentials, the museum's workshop is a gun action filer's shop of about 1900 or earlier, and it contains a very large and representative collection of hand tools, including a percussioner's hand brace which is now probably unique. There is no machinery except a small treadle lathe, which was used for drilling action-pin holes. All the tools have been used for long periods; the shop was, in fact, in daily operation until the death of the proprietor in 1948.

BRASS AND GOLD

Also of about the 1900 period is the brass turner's shop. This has a 7 in lathe, driven by a Crompton Parkinson d.c. motor of 1890, through a countershaft and belting. The lathe is typical of those used in the Birmingham brass-foundry trade for turning such items as cocks, ships' fittings, bedstead fittings and cabinet brassfoundry. Brassware was usually made in small to medium-sized factories (as it still is), and, as a rule the turning shop would contain several lathes in line. Only by having a single lathe does the museum's shop differ from the type of shop which can still be found in use in the area.

Jewellery is a celebrated Birmingham product, and the trade has always possessed many highly-individual features. The museum's workshop, which is about 9 ft square, not only represents the period around 1900, and an earlier time, but is also typical of the present day in many ways. As will be seen from the accompanying illustration, the shop possesses a "five-pin board." This name is that given to a five-seat bench at which five individual craftsmen could work, and the stools on which the men sat, and the leather aprons fixed to the bench to catch the

Continuing Production

gold filings, are all in position. As at present equipped, the shop has tools for three craftsmen: an engraver, a jeweller (who builds up the ornamental piece) and a gem-setter. Here again, there is no power machinery. The workers made their own precious-metal wire in a hand draw-bench, from slit sheet, rounded by hammering. Small hand-operated rolls were used for wire flattening. All the rest of the work was done at the bench, which is equipped with gas jets for use with mouth blowpipes for soldering. Concentrated spot lighting was necessary for the small delicate work done by the jewellers, and the traditional method of providing it was by means of a central fishtail gas jet (or earlier, a candle), and glass globes filled with water. One of these globes placed in front of each worker acted as a cheap and surprisingly effective lens, and directed the light just where it was wanted. A full set of globes, together with the gas jet, forms part of the equipment of the shop.

In the cooper's shop, too, which is typical of the period 1900 to 1930, hand work was the invariable rule. Wet coopering was carried on with the traditional hand tools, and the museum's shop, which is a composite exhibit typical of the Birmingham one-man business, would have a size range of from half a gallon to 100 gallons.

The nailmaker's shop, a view of which is reproduced on the previous page, is ageless. As far as can be ascertained, the equipment changed but little, if at all, throughout the long history of the trade, which has only become extinct in the Midlands since the war. The museum nailer's shop could therefore just as easily represent the year 1850 as that of 1950, when it actually ceased work; the old nailer concerned being then some 90 years of age. Only about 12 ft square, the shop contains the most primitive equipment, nothing in the way of machinery being provided. An "Oliver" or spring-pole treadle hammer, erected in working order like all the other exhibits, is the only device which the nailer had to lighten his labour. It is the same with the two older shops, the silversmith's and the brassfounder's as with the latest exhibits. There is no machinery, except a small lathe in the silversmith's, and the shops are small and bare of anything but the essentials.

AN INDUSTRIAL CROSS-SECTION

Taken as a whole, the shops are fairly representative of a large section of Midland industry in the latter part of last century. If they look dirty and rather dismal, it is because great pains have been taken to make them do so, for that is how they were in fact. Heating was non-existent, ventilation of the most primitive type, and artificial lighting, if provided at all, equally rudimentary. Even natural lighting usually left much to be desired. Times have certainly changed, but it is as well to pause and reflect that the old men were not always quite so primitive as we might think. There was order in the apparent chaos of the workshop; tools were placed just where they would next be needed, and those who have been privileged to see some of the old craftsmen at work will testify to their skill and, what is more, to the intelligent way in which their work was done. A study of an old nailmaker at work, for example, revealed that he never wasted a movement of his hands, feet or body. He had never heard of motion study, but it had nothing to teach him.

It has already been said that the basic idea of all the displays is to give the impression that work could start at once. In the first two workshops to be completed the public see the exhibit through a large glass window; the cooper's shop is also glazed, this being done for reasons of internal organisation, but in the three remaining shops only a barrier, 3 ft high, topped with a glass screen to a further 1 ft 2 in, keeps the public out of the shops. A shelf on the public side, at 3 ft above floor level, is a silent invitation to lean and contemplate, and there is a curiously satisfying feeling of being inside the shop; the physical barrier gives way to a psychological freedom.

Special Article

FLOW OF HEAT IN

By T. Ferguson,
A.M.I.E.E.

Very often insight into a complex problem of many variables is achieved by consideration of one specific instance of the problem. Such an approach to the warming of a room by an open fire is provided by this article, which describes the work carried out by the author when, dissatisfied with the performance of his fire, he decided to improve it. Although an engineer, he had not had experience in testing domestic fires; for many years, until his retirement, he was chief engineer of traction projects (later, consulting engineer on traction) with Metropolitan-Vickers Electrical Company Limited. Thus his approach was not that of the fuel research engineer and his results do not add significantly to the existing literature on the subject. But, for engineers unaquainted with this field, his work provides an insight into the factors governing the efficiency of a fire.

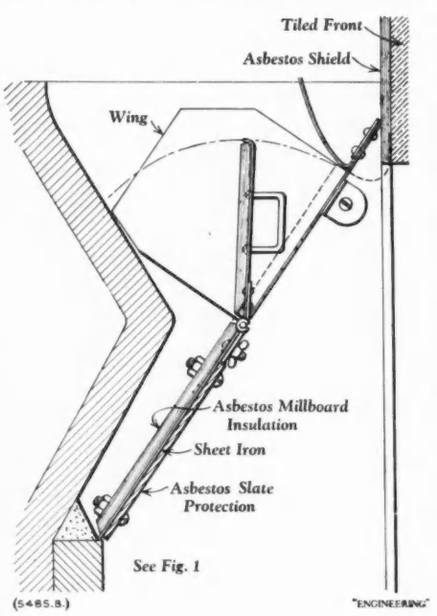
In some houses, especially old ones having chimneys with large outlet pots and unrestricted throats, the quantity of air passing from the room up the chimney over an open fire, is excessive, to say the least.

This air consists of the relatively small quantity required for combustion, together with the much greater amount of induced air. As the air originally comes from outside the house, it is heated to room temperature by the fire and any background heating that may be in use. The amount of heat thus lost, can, when background heating is used to keep the room at, say, 60° F, be at times as much as the fire is contributing to the room.

The resistance offered by the "chimney circuit" to the air flow, must balance the "chimney head" that is produced by the sensible heat losses from the fire which pass up the chimney. Under definite conditions, it is possible to arrive at an approximate estimate of the airflow.

Fig. 1 shows to scale, the writer's 16 in fireplace which has been, he believes, largely spoilt when fitting a gas-ignited coke-burning grate. The sloping forward part of the fireback seldom or never gets hot enough to burn off the soot deposit and thus fails to contribute its quota of high temperature radiation. The throat is wide and offers little restriction to airflow. Also, there is a large angle of lost radiation upwards from the fuel.

As a first step, the throat restrictor shown in



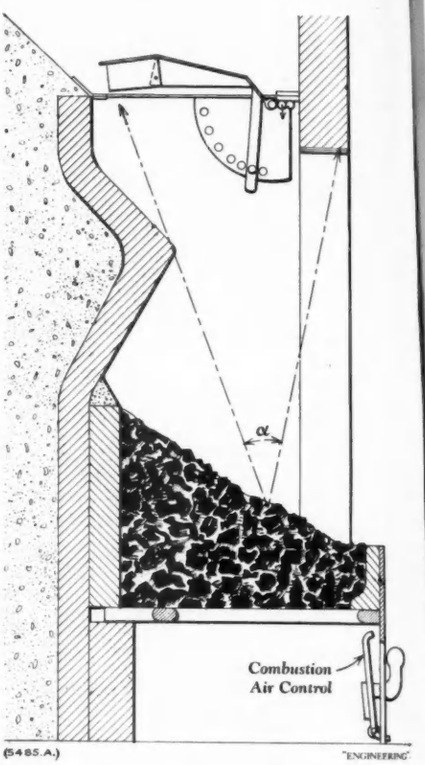


Fig. 1 The sloping back of the fire seldom got hot enough, and there was a large angle of lost radiation upwards from the fuel. The first throat restrictor is shown fitted.

Fig. 1 was fitted to reduce the heat lost by excessive airflow, as the unrestricted airflow, when burning fuel at the rate of 2 lb per hour (equal, say, to 25,000 B.t.u. per hour) was estimated to be of the order of 15,000 cu. ft per hour when the chimney pot was clean. This loss when the room temperature is 60° F and outdoor temperature 40° F, is $\frac{15{,}000 \times 20}{54}$ =5,550 B.t.u. per hour, which is 22 per cent of the calorific value of the burning fuel, and a bad fire might fall to that efficiency. (One B.t.u. will raise 54 cu. ft of air 1°F.)

The throat restrictor reduced the ventilation loss to a reasonable amount. It was found necessary to open it wide when lighting the fire, adjusting it later to suit the state of the fire. A certain amount of airflow is necessary to prevent stray currents of air in the room disturbing the upward movement of the smoke, but assuming that 5,000 cu. ft per hour is sufficient, the restrictor reduces that particular loss to one-third. At certain states of the fire, probably a lower airflow would suffice, while some fires may remain smokeless with 3,000 to 4,000 cu. ft per hour.

Fitting the throat restrictor, of course, made no difference to the temperature of the fireback, so it seemed to the writer that the sloping forward part should be extended to meet the back of the tiled mantle facing, leaving only a sufficient,

Fig. 2 An adjustable backplate was added and the increased radiation was clearly felt.

IN A ROOM WITH FIRE AND CHIMNEY

adjustable opening to let the smoke pass. To this end, the adjustable backplate shown in Fig. 2 was fixed, replacing the original throat restrictor. It consists of a piece of sheet iron cut to fit, and has a gap of about 8 in wide cut out from the top. A metal strip is riveted across the top of the gap and has an air guide of tinplate secured to it. Side wings of sheet iron are riveted to the main piece at each side of the gap, which is filled by a hinged flap. Asbestos millboard is fixed over the back for heat insulation. The asbestos on the flap also provides sufficient friction with the wings to keep the hinged flap in any desired position and so gives a simple throat restrictor. The whole device should be made of stainless steel, or at least the lower part should be, to withstand the heat. This material not being to hand, the experiment was made with a protective facing of asbestos slate which was not expected to last long, if the idea was a success. In fact, it lasted two months before renewal was necessary, as it got red hot. The benefit was clearly felt, in the increased radiation comfort and in a small rise in room temperature.

However, research workers in this field have only found second order increases in radiation efficiency in improvements on the " Milner " fireback, so it appears that the writer has merely converted a bad fire into an ordinary one.

Some background heating is necessary in the writer's room to get adequate comfort; it has a capacity of 3,000 cu. ft and about 80 sq. ft of window. Many houses do not have any background heating and in the writer's house, when it is not operating, the room temperature falls considerably below 60° F. Then, a balance has to be attained such that the heat contributed from the fire is equal to the loss of heat due to the airflow plus the loss from conduction of heat through walls and window glass, both losses being reduced with the room temperature.

Fig. 3 shows graphically the approximate airflow and the net heat lost or gained from the writer's fire of assumed 25 per cent efficiency at all rates of burning fuel. The room temperature is maintained at 60° F and the outside at 40° F. The dotted lines are when the chimney is unrestricted, and the full lines are when the air flow is reduced to about one-third. A more efficient fire will push the points of equal gain and loss of heat towards zero fuel consumption and also make the gain curve steeper.

RESISTANCE CHARACTERISTIC OF THE CHIMNEY CIRCUIT

The greater the total resistance of the " chimney circuit," the less will be the airflow for any given rate of sensible heat lost up the chimney. The total resistance consists of the following losses of " head " in the circuit:—

(*a*) At entry into house and room.

(*b*) At the chimney throat: this can be increased at will by fitting a throat restrictor.

(*c*) That due to the friction of the air passing through the flue.

(*d*) That due to the discharge velocity " head " at the outlet.

All these losses of " head " are proportional to the square of their respective air velocities and directly to their densities.

While some of the kinetic energy of the air velocity is recovered at entries and throat, as and when the velocity diminishes, it is totally lost at the chimney pot outlet. Accordingly, its area becomes of paramount importance, and generally represents a large part of the total resistance, and this part varies inversely as the fourth power of the outlet diameter.

On Fig. 4 is shown the approximate loss characteristics of the writer's 35 ft chimney under contrasting conditions. The right-hand curve is for a clean pot (area 0·375 sq. ft) and the left-hand curve is when it was fouled sufficiently to cause a smoky fire: it was found to have a hard deposit near the outlet which reduced it to 3½ in diameter (0·067 sq. ft) or less. Thus the airflow was drastically reduced and was insufficient to ensure smokelessness. An approximate chimney head curve is shown for 12,200 B.t.u. per hour sensible heat escaping up the chimney. (About 50 per cent of 25,000 B.t.u. per hour fuel burning rate.) The room temperature is 60° F, outside it is 40° F.

The air flow with the clean pot is rather more than 250 cu. ft per min (15,000 cu. ft per hour) and with the fouled pot, about 4,500 cu. ft per hour. Although the chimney head curve is only an approximate estimate, it will be noticed that errors of, say, 20 per cent show only relatively small changes in air flow.

The obvious thing to do is to keep the pot clean and regulate the air flow by a throat restrictor, but unfortunately, burning quantities of fire logs with other fuel does cause a hard deposit to form inside the pot and the sweep's brush may merely clean off the soft soot lying on it, thus requiring frequent sweeping. The final cure is to chip away the hard deposit.

With regard to the components of chimney loss, the head lost at the outlet is $\frac{V^2 m}{1{,}207{,}000}$ inches water gauge, where V is in ft per min and m is the weight of one cu. ft of air at the temperature of the outlet

$$m \text{ is } \frac{1{\cdot}33 \times \text{Bar. press. in inches mercury,}}{461 + \text{temp. in deg. F.}}$$

lb per cu. ft.

So to be accurate you should estimate the outlet temperature and so get the outlet velocity and m.

For the loss of head up the chimney we can take a common empirical formula, namely,

$$\text{lost head per 100 ft of flue} = \frac{0{\cdot}42\ V^2}{X} \text{ in inches}$$

water gauge.

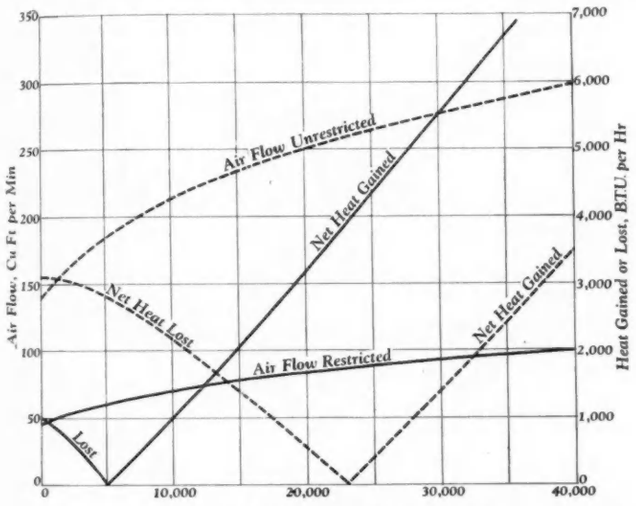


Fig. 3 The approximate airflow and net heat lost or gained, assuming 25 per cent efficiency at all rates of burning fuel.

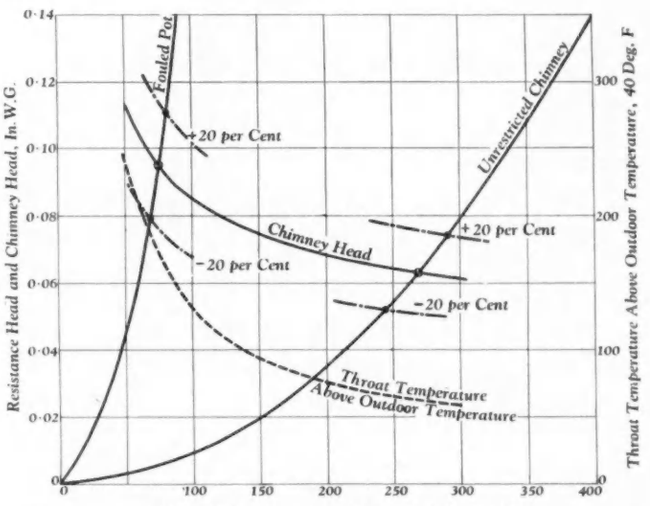


Fig. 4 The approximate loss characteristics of the writer's 35 ft chimney.

$$X \text{ is } \frac{\text{area of flue, sq. in}}{\text{perimeter of flue, in}}$$ i.e., 2·25 for a 9 in by 9 in flue. Now, V is in thousands of feet per minute, so as it is mostly less than 1,000 ft per min and the flue is only a fraction of 100 ft, the flue loss is only a small proportion of the total. It is advisable to add 25 per cent to the above formula to cover for increased velocity with reduced density due to expansion and for roughness in surface.

The entry losses depend on the size of cracks round doors, windows and floor boards. A measure of the resistance offered by the room entrance, can be had by measuring the pull on the door at its centre of pressure and the area of the door. It is interesting to notice the marked drop in pressure when reducing the airflow by a throat restrictor. Entry losses into the house as a whole should be low enough to avoid down draughts in cold chimneys, the approximate head of which can be estimated from their room temperature.

As regards the " chimney head," this is the difference in weight between a column of air of 1 sq. ft section at outdoor temperature and a corresponding column at the mean effective temperature of the chimney. This " head " is in lb per sq. ft (convert to inches water guage by dividing by 5·208). The difficulty is, of course,

Continuing

Flow of Heat

to estimate the mean effective temperature of the hot column, and resort may be made to published results of tests by the Fuel Research Station. It is of interest, however, to have a shot at it oneself to get some understanding of the variables involved, although the theory is rather complicated.

For any given rate of sensible heat lost from

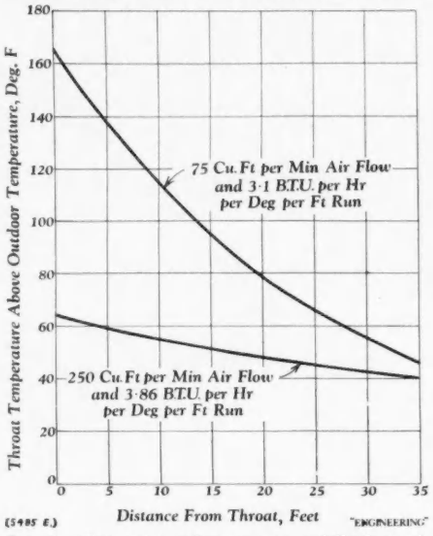


Fig. 5 Estimation of temperature fall along the length of an 18 *in square chimney stack exposed to outside air.*

the fire up the chimney, for example, 12,200 B.t.u. per hour (11,000 cu. ft deg. F per min) we get the temperature rise of the air at the throat by dividing the cu. ft deg. F per min by the cu. ft per min of the air leaving the room to go up the chimney. This rise plus room temperature is the throat temperature, and when the outside temperature is deducted we get the maximum temperature gradient—throat to outside. This is indicated as a dotted curve on Fig. 4.

The rate of heat loss from the flue to the outside and to the inside of the house will be at a maximum at the throat, and diminish progressively along the chimney as the temperature falls. It depends on surface resistance and brickwork resistance. The surface resistance is quite important, otherwise steel chimneys would lose their heat too rapidly. The usual surface resistances used in calculating heat losses from buildings are outside 0·3 and inside 0·7, and brickwork resistance equals inches thickness divided by eight. The outside resistance is low because of winds, but if, say, air at about 250 cu. ft per min was passing up the flue, its speed would be 5 m.p.h., so presumably its surface resistance might approach or even reach 0·3. On the other hand, if the airflow were restricted to 75 cu. ft per min the inside of flue resistance might approach 0·7.

Fig. 5 gives a rough idea of how temperatures might fall along the length of an 18 in square chimney stack exposed to outside air. The top curve is based upon 3·1 B.t.u. per hour per degree difference per foot run, and the lower one on 3·86, i.e. $\left(\frac{1}{0{\cdot}3 + 0{\cdot}3 + \frac{4\frac{1}{2}}{8}}\right) \times 4\frac{1}{2}$ ft (mean perimeter). One can say that, generally, in most homes, these rates will be rather lower for obvious reasons.

With regard to the top curve the first foot run will dissipate about $3{\cdot}1 \times 164 = 510$ B.t.u. per hour $= \frac{510 \times 54}{60}$ cu. ft deg. F per min. Dividing that by the air flow of 75 cu. ft per min, we get a temperature drop of 6·1°F and so on, progressively less.

The mean heights of these curves, however, do not give us the mean effective temperatures for our purpose, because the "m" formula does not follow quite a straight line, but we can calculate the "head" for, say, each foot of chimney and so get the total "head." Low rates of sensible heat lost up the chimney will produce lower temperature gradients and give lower chimney "heads." It will be realised that the height of the chimney makes a relatively small difference in the air flow because of the square law resistance, and the loss in temperature in a low chimney is not so great as in a high one. This approximate treatment gives a rough idea of a most interesting problem containing many variables.

Engineering at Home

COMPACT AIR CONDITIONER

A new air cooling and dehumidifying unit has recently been introduced by Temperature Limited, Fulham Road, London, S.W.6. The "Tropical" air-cooled 1·5 h.p. room conditioner is suitable for 190-210 or 220-250 V, single phase, alternating supply. It has been designed for use in areas with high relative humidities, and can cool the average size modern room or office.

The evaporator coil is fitted with a finned sub-cooling coil between the inner coil and the air exit grill. In this way the relative humidity of the leaving air is reduced and condensate does not form on the facia during very humid weather. A centrifugal fan driven by a capacitor-start motor delivers about 300 cu. ft per min of air from the unit. The motor is tropicalised and has a double shaft, a six-bladed kidney-shaped condenser fan also being driven. Condensate disposal is by a slinger ring attached to the periphery of the condenser fan. The evaporator is protected against frosting under light load by a thermostat. The facia has a rotatable discharge grill to control the direction of the air flow.

The unit is designed to cool the average size modern room or office.

FREQUENCY MODULATION FOR WALES

The BBC has placed an order with EMI Electronics Limited, Hayes, Middlesex, for six frequency modulated transmitters for the v.h.f. sound station now being built at Llanddona, North Wales. Some 180,000 people living in Anglesey and North Wales will receive the three main BBC programmes from the station. Six similar transmitters have also been ordered for the new station to be built at Nether Button, Orkney.

The method of modulation used is direct frequency modulation of an oscillator operating at half carrier frequency, with audio frequency feedback from a frequency demodulator fed from the oscillator. Centre frequency stability is achieved by the use of an independent feedback circuit. The company claim that their method results in a high signal-to-noise ratio and low harmonic distortion.

The BBC transmitters are designed to operate in Band II (87·5 to 100 Mc/s) at 1 or 2 kW output. Duplication of the complete transmitter and operation of the two units in parallel ensure greater reliability of service, as transmission will be maintained should a fault develop in one unit. Easy accessibility to all valves and components is provided by mounting each unit vertically and suspending it within its cubicle on telescopic rails. The equipment is designed for fully remote controlled operation.

TO LOWER VOLTAGES

The use of step-down transformers in conjunction with portable electrical equipment considerably reduces the risk of accidents from electric shock. A transformer suitable for this function and operating from a standard mains supply is produced by Parmeko Limited, Ayleston Park, Leicester. It is available with 12, 25, or 50 V outputs.

An earthed copper screen between primary and secondary windings ensures that no dangerous voltages can be transferred to the secondary. Should it be necessary to renew the fuses, the supply voltage is immediately disconnected from the transformer on removing the cover. The transformer complies with B.S.171 and B.S.794; it is proof against moisture and suds.

On removing the cover to replace a fuse, the supply voltage is disconnected.

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